October 2021

San Diego Regional Decarbonization Framework

DRAFT – NOT FOR CITATION

School of GLOBAL POLICY & STRATEGY

SDG POLICY INITIATIVE

Table of Contents

Introduction

Recognizing the need for a regional approach to addressing climate change, on January 27th, 2021, the San Diego County Board of Supervisors voted to create a Regional Decarbonization Framework. This framework is intended to inform policy making in regional, county and city governments towards reducing greenhouse gas emissions in the San Diego region. It is separate from but complements ongoing climate action planning efforts by local governments, as well as regional planning in energy, transportation and land-use.

This study is the first step in positioning the region as a global leader in climate planning. It is authored by a team led by the University of California San Diego School of Global Policy and Strategy, working in collaboration with the Energy Policy Initiatives Center at the University of San Diego School of Law and other consultants with technical expertise in energy, transportation and building systems. The analysis employs energy systems modeling to guide sector-specific analyses in the geospatial aspects of electricity infrastructure, potential for natural climate solutions, gaps in transportation sector strategic plans, opportunities and challenges in the building sectors, and an analysis of impact of jobs during the transition to decarbonization. A local climate policy database is used to identify gaps in the policy landscape to put all the region's jurisdictions on a path to zero carbon emissions.

The Regional Decarbonization Framework is intended to anchor the San Diego region in emerging best practices from across the nation and globally. It seeks to chart science-based pathways towards deep decarbonization that can be implemented in a feasible and expeditious timeline. It proposes a paradigm shift in our local economy. The scale and pace of this effort will require partnerships between public and private sectors, particularly, business, labor and environmental communities. We will therefore continue to seek input and involvement from all stakeholders as we begin the process of implementing the goals outlined in this framework.

Murtaza H. Baxamusa, PhD, AICP
Program Manager for Regional Sustainability
Land Use and Environment Group
County of San Diego

Project Team

Project Director

Gordon C. McCord

Director, SDG Policy Initiative

School of Global Policy and Strategy, University of California San Diego

Project Manager

Isaac Wang, UC San Diego

San Diego County Representatives

Murtaza Baxamusa, Program Manager for Regional Sustainability, County of San Diego

Rebeca Appel, Program Coordinator, Land Use and Environment Group

Chapter authors:

Study Approach

Ryan Jones, Evolved Energy Research

Geospatial Analysis of Renewable Energy Production

Emily Leslie, Montara Mountain Energy

Joseph Bettles, UC San Diego

Accelerating Deep Decarbonization in the Transportation Sector

Katy Cole, Fehr & Peers

Chelsea Richer, Fehr & Peers

Eleanor Hunts, Fehr & Peers

Natural Climate Solutions and other Land Use Considerations

Elise Hanson, UC San Diego

Emily Leslie, Montara Mountain Energy

Decarbonization of Buildings

Asa Hopkins, Synapse Energy Economics

Philip Eash-Gates, Synapse Energy Economics

Jason Frost, Synapse Energy Economics

Shelley Kwok, Synapse Energy Economics

Jackie Litynski, Synapse Energy Economics

Kenji Takahashi, Synapse Energy Economics

Employment Impacts through Decarbonization in the San Diego Region

Robert Pollin, PERI, University of Massachusetts Amherst
Jeannette Wicks-Lim, PERI, University of Massachusetts Amherst
Shouvik Chakraborty, PERI, University of Massachusetts Amherst
Gregor Semieniuk, PERI, University of Massachusetts Amherst

Key Policy Considerations for the San Diego Region

Joseph Bettles, UC San Diego
Gordon McCord, UC San Diego
David Victor, UC San Diego

Local Policy Opportunity Analysis

Scott Anders, Energy Policy Initiatives Center, University of San Diego
Nilmini Silva Send, Energy Policy Initiatives Center, University of San Diego
Joseph Kaatz, Energy Policy Initiatives Center, University of San Diego
Yichao Gu, Energy Policy Initiatives Center, University of San Diego
Marc Steele, Energy Policy Initiatives Center, University of San Diego

San Diego as a Model

Elena Crete, Head of Climate and Energy Program, UN Sustainable Development Solutions Network (SDSN)

Appendix A: Summary of Statewide Energy System Modeling

Ryan Jones, Evolved Energy

Appendix B: Public, Public Agency and Stakeholder Outreach

Isaac Wang, UC San Diego
Andy Pendoley, MIGCOM
Joey Nielsen, MIGCOM

Acknowledgements: The RDF team thanks David Victor for his advisory role across the project, as well as Joseph Bettles, Emily Carlton, Elise Hanson and Tyler Spencer for research and editorial support.

1. Study Framework

Ryan Jones, Evolved Energy Research

Key Takeaways

- Regional and local decarbonization policies should be informed by detailed analyses of the energy, transportation, and land use sectors, and these should be consistent with a system-wide path to decarbonization at regional, state, and national scales.
- Sectoral analyses in this report are informed by the results of energy system modeling at a state and national level that outline pathways to net-zero emissions, described in more technical detail in Appendix A.
- Technical pathway studies are valuable for identifying dead-end strategies; identifying key decision points; identifying commonalities in pathways under sensitivity analyses; and situating near-term policy targets with respect to long-term goals.
- Uncertainty necessitates an ongoing planning process, with periodic updating as new information becomes available and as progress, or lack thereof, toward goals is achieved.

1.1 Introduction

The Paris Agreement calls for "holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C."[1] Following the scientific evidence and consensus around climate change, countries and local jurisdictions around the world have begun adopting the goal of reaching carbon neutrality, or "net-zero." Executive Order B-55-18 directs California to reach such a target by 2045.

This Regional Decarbonization Framework (RDF) presents a science-based approach to help governments in the San Diego region plan for policies and investments to achieve emissions reductions consistent with this state target. The analytical approach consists of two main pieces. First, models of the whole energy system, both at national and state levels, are used to identify five technically and economically feasible pathways for achieving net zero emissions. Second, these results are used to guide detailed sector-level analyses for the San Diego region to best follow these pathways. The rationale for this analytical structure follows.

The RDF begins with the premise that regional and local policies should be informed by detailed analyses of the energy, transportation, and land use sectors, and that these should be consistent with a system-wide path to decarbonization at regional, state, and national scales. Due to the complexity of our energy and climate systems, many analytical approaches examine a single sector at a time, often in great detail, but do not explicitly consider interactions between sectors. With such an approach, there is a risk that the cumulative actions from each sector are either insufficient, unbalanced with respect to cost/effort, or that interactive effects lead to unintended negative consequences (e.g., multiple sectors decarbonizing through the use of biomass, leading to unsustainable reliance on the resource). To help avoid such an outcome, sectoral analyses in the RDF are informed by five pathways to net-zero emissions identified by state and national-level models of the whole energy system. This systems-level pathways analysis was performed by Evolved Energy Research using models EnergyPATHWAYS and RIO, and is based on the methodology and data in an earlier, national-level pathways analysis by Williams et al. (2021),[2] which also used these models. The modeling effort will hereafter be called the Evolved Energy Research (EER) models. For the RDF, modeling tools were updated for consistency with the 2021 EIA Annual Energy Outlook and specific zones were created for Northern and Southern California to aid in downscaling the insights from the U.S. at large. Methods, key assumptions, and results of energy system modeling are presented for the state-level in Appendix A and for the national-level in Williams et al. (2021).[2] Importantly, in instances where the particular circumstances in the region differed from those at a state or national level, the San Diego specific insights were retained. Thus, the blueprints (or "pathways") for the larger geographic areas were used to inform, but not to prescribe.

Guided by the energy system decarbonization pathways for California as a whole, pathways analysis within each sector in the RDF details what would be needed (e.g., infrastructure investments, local policy commitments, or policy action in other domains) so that the San Diego region is in alignment with a net-zero emissions trajectory for California. Sector-level pathways are necessary because technical and political challenges vary by sector, and so too will a practical policy strategy. Of note, each sector is not expected to arrive at net-zero emissions independently; rather, each sector is expected to work in conjunction with other sectors and California regions as an interconnected system to reach decarbonization goals.

In line with California's commitments and with the California-wide energy system analysis, the RDF is guided by a system-wide technical pathway that achieves decarbonization by 2045 - the system-wide approach helps to ensure consistency of effort and overall success in reducing emissions but is not a straitjacket that informs what must be done in each sector. While aiming to decarbonize sooner may be desirable from the climate standpoint, national, state, and local governments need to move in concert in their policies and investments in order to achieve decarbonization, given the interconnected nature of the energy system.

The following chapters of this report detail how the electricity, transportation, land use, and buildings sectors contribute to technical pathways for arriving at net-zero emissions. The RDF focuses on these sectors because they are major contributors of greenhouse gases, and each contain policy levers relevant to county and city government.

This report does not set out to identify which, if any, of the pathways is the "right" pathway for the San Diego region because the best pathway is, at this moment, impossible to know. Instead, it shows multiple ways forward in order to elucidate the tradeoffs, decision points, risks, and synergies in decarbonization. This is a unique effort to chart out how to reduce carbon emissions in the region, and it aims to foster collaboration among various municipalities while positioning the region to attract state and federal resources. Decarbonization will require that each level of government utilize policy levers within its respective jurisdiction, but also collaborate vertically and horizontally across jurisdictions to align long-term goals. The RDF provides policymakers, private industry, and stakeholders in the San Diego region the information needed to chart a path forward, starting with policies necessary to reach interim 2030 targets. It also proposes a framework of regional institutional governance that emphasizes collaborative policy experimentation and review across governments, industries, and academia, with the understanding that such cooperation can allow goals, strategies, and policies to improve over time as lessons are learned and circumstances change.

1.2 Study Questions

The research team set out to answer two primary questions: (1) what changes are required to infrastructure, patterns of energy use, or in the land sector for the San Diego region to decarbonize consistent with the state's goals; and (2) what policy actions must be taken at a local level for the region to achieve these changes?

It is taken as a given based on past modeling exercises that reaching net-zero in California by 2045 is both possible and can be done so at manageable cost—indeed, monetary savings from air quality improvements or avoided adaptation cost are expected to be larger than costs. At the same time, the RDF recognizes that many policies necessary for reaching net-zero emissions are controlled at the state or federal level and not by local governments. The San Diego region can be a vocal advocate for these policies (e.g. federal tax incentives), but the content of what needs to be achieved in these other jurisdictions are not a focus in the study.

1.3 The Role of Pathways in Planning

The discussion of the role of pathways in planning below draws heavily from a recent report from the Commonwealth of Massachusetts.[3] Rather than simply referring the reader to that report, we have reproduced part of that text here to highlight key ideas.

The RDF uses the term “pathway” to mean a blueprint for the energy system that reaches future GHG reduction targets. The term can refer to both a specific strategy and to a set of different possible blueprints (as in, “multiple pathways to deep decarbonization”). The term “pathway” was first used by the Deep Decarbonization Pathways Project (DDPP) in 2014[4] and was coined to capture the path dependency within different decarbonization strategies. While the physical transformations represented by these pathways are informed by economic, social, and political constraints, they should not be mistaken for the impacts of a specific policy or market intervention.

The study of long-term decarbonization pathways has been a growing trend after early success using them in California. Modeling decarbonization pathways depends on the ability to represent the existing energy system with a high degree of accuracy. Significant effort goes into benchmarking and stress testing the models of current energy systems until researchers have a high degree of confidence that changes in inputs will produce meaningful outputs. After California, other states (Washington, New York) followed suit with their own pathways analyses. Pathways analysis has become an integral part of energy planning processes, and yet, because of the breadth of topics covered, and the time horizon analyzed, it is still a unique activity within state-level public policy processes and merits some clarification.

The most critical clarification is that pathways are not forecasts of what will happen. While the energy system physics and emissions accounting that underpin our models are well-established, projecting technological progress (particularly cost) and energy service demand has a mixed track record, even over time spans much shorter than 30 years. This means that selecting a single pathway as the basis for public policy is fraught because the assumptions that cause it to be a better option in the present may shift over time. Uncertainty necessitates an ongoing planning process, with periodic updating as new information becomes available and as progress, or lack thereof, toward goals is achieved.

Rather than providing a prediction of the future, pathway studies are valuable for four reasons:

- Identifying and lowering the risk of dead-end strategies;
- Identifying key decision points;
- Identifying commonalities in pathways under sensitivity analyses;
- Situating near-term policy targets with respect to long-term goals.

Infrastructure that produces, delivers, and consumes energy is capital intensive and has long lifetimes. This is illustrated in Figure 1.1, which shows the number of replacement cycles for common infrastructure types between now and mid-century.[3] If a pathways analysis looked only 10 to 15 years ahead, as is typical in electric utility integrated resource plans, and decisions were made that would efficiently reduce emissions to hit near-term targets but were inconsistent with long-term goals, then those decisions would lock in higher emissions or increase costs necessitating early retirement. Thus, a 30-year pathways study is able to test a given decarbonization strategy against this backdrop of infrastructure lifetimes in order to understand whether an emissions dead-end will be encountered on a given path. Knowing the timing of key decision points can also help to avoid stranded assets.

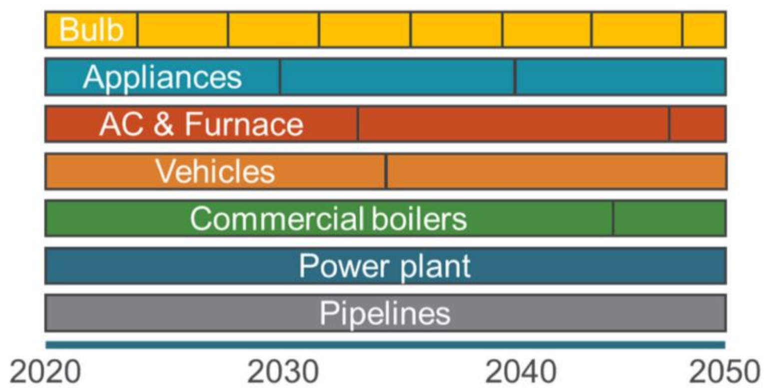


Figure 1.1. Overview of the lifetimes of common energy consuming or producing infrastructure. A simplified overview of the lifetimes of common energy consuming or producing infrastructure are compared against the 30-year time period left to reach the net-zero target. The black vertical lines delineate points of natural retirement, and the number of segments correspond to the number of replacement cycles between now and 2050. The lifetime of vehicles by location and duty-cycle. The lifetime of power plants and pipelines is longer than 30 years and thus no natural retirement is shown on this figure.

As mentioned, the future trajectories of many variables, including technology cost and performance projections, are highly uncertain. However, it is possible to develop ranges of values in which the high and low estimates have a high probability of encapsulating the eventual revealed value for any variable. Creating multiple pathways within each sector allows us to test the sensitivity of results to a range of input assumptions. The most useful result is not a precise blueprint embodied in any specific pathway but is a framework identifying those strategies that are common across all pathways, as well as the drivers of differences among pathways. As will be detailed later in this report, a set of strategies can be identified over the next 10 years that are common to all modeled pathways that successfully reach the net-zero target.

Finally, pathways studies can be valuable in near-term target setting. Back casting from a mid-century net-zero energy system to the present allows the identification of certain milestones or benchmark values (often ranges) that are consistent with being on track to reach the long-term goals. Near-term targets and policy recommendations will be discussed in more detail in the chapter titled “Key Policy Considerations for the San Diego Region.”

1.4 Notes on reading this report

Readers of this draft report should be aware of the following:

- This report is a draft, and both details of the modeling analyses and the implications are subject to change before the work is finalized in February 2022.
- Throughout the report, we use the term “San Diego region” when referring to the geographic extent of the county, and “San Diego County” to refer to the county government.
- Readers interested in high-level findings and recommendations for an institutional framework to promote decarbonization are encouraged to read Chapter 7 on “Key Policy Considerations for the San Diego Region.” To inform the institutional structure and processes, Chapter 7 provides an overview of key decarbonization actions, areas of uncertainty, and County leverage points from each of the four sectors: land use, buildings, transportation, electric sector. The overview in Table 7.1 provides the basis of several takeaways that are used to inform a proposed institutional structure to support decarbonization implementation among the range of policy actors in the San Diego region.

Works Cited

1. UNFCCC. *Paris Agreement to the United Nations Framework Convention on Climate Change*.; 2015. https://unfccc.int/files/meetings/paris_nov_2015/application/pdf/paris_agreement_english_.pdf
2. Williams JH, Jones RA, Haley B, et al. Carbon-Neutral Pathways for the United States. *AGU Adv*. 2021;2(1):e2020AV000284. doi:10.1029/2020AV000284
3. Jones R, Haley B, Williams J, Farbes J, Kwok G, Hargreaves J. *Energy Pathways to Deep Decarbonization: A Technical Report of the Massachusetts 2050 Decarbonization Roadmap Study*. Commonwealth of Massachusetts; 2020.
4. Deep Decarbonization Pathways Project. *Pathways to Deep Decarbonization 2015 Report*. SDSN - IDDRI; 2015.

2. Geospatial Analysis of Renewable Energy Production

Emily Leslie (Montara Mountain Energy)
Joseph Bettles (UC San Diego)

Key Takeaways

- This chapter identifies low-impact, high-quality areas for wind and solar development in San Diego and neighboring Imperial County.
- The region has sufficient available land area for wind and solar generation to approach a fully decarbonized energy system in line with the California-wide system model in Appendix A.
- However, approaching a 100% decarbonized energy system that also meets societal expectations and regulatory standards for reliability will require significant but uncertain investments in a suite of additional resources, including excess intermittent and flexible generation, storage, and demand-side management.
- The chapter informs decision-making by providing a series of site-selection scenarios that prioritize land value, ease of development, and environmental impact as well as proposing a strategy for addressing reliability.
- The significant solar and geothermal potential of neighboring Imperial County is a large potential resource for San Diego that may require upgrades to the transmission network.
- The County should coordinate with state agencies (CPUC Integrated Resource Planning team, CPUC Resource Adequacy team, CAISO Transmission Planning Process team, CAISO Local Capacity Requirements team) to ensure the reliability of the system.

2.1 Introduction

Decarbonization of the electric sector in San Diego County will require substantial deployment of new renewable resources; 90% of the electricity in most decarbonization scenarios comes from commercially mature renewable technologies such as wind and solar. Decisions on where to site wind and solar photovoltaic (hereafter solar) facilities can have significant impacts on the environment[1] and require development of new and upgraded transmission infrastructure.[2] In this chapter of the Regional Decarbonization Framework (RDF), we use the modeled electricity demand from the Central Case of the Evolved Energy Research (EER) model[i] and identify low-impact, high-quality areas for wind and solar development in San Diego County, and compare the resource potential to the modeled 2050 demand forecast for a fully decarbonized economy,

[i] For more information on the macro energy modeling, see Appendix A.

in order to comment on magnitude and scale of anticipated supply and demand. This report also considers an alternate site selection scenario that assumes power transfer between San Diego and Imperial County, as well as four additional scenarios with site selection prioritized on the basis of environmental protection, pecuniary land value, carbon sequestration potential, and developable land. We also estimate the costs and capacity addition of prioritizing urban infill and rooftop solar. We discuss the potential co-benefits of rooftop and urban infill ground-mounted solar, including equity benefits such as local economy job creation and pollution-reduction. Finally, we present least-cost actions in the near-term which are valid across site selection scenarios. The electric sector spatial analysis is intended to inform planning and deployment of renewable electricity capacity in the region based on a range of techno-economic and environmental variables including cost of energy, environmental impacts, and resource availability.

2.2 Data

RETI Candidate Project Areas

To identify the resource potential of utility-scale solar and wind energy generation in San Diego and Imperial Counties, this analysis considers candidate project areas (CPAs) - land areas where renewable development is possible - identified in the 2009 Renewable Energy Transmission Initiative (RETI).[3] The RETI CPAs were selected through a collaborative process between California Public Utilities Commission, the California Energy Commission, the California Independent System Operator along with local utilities and a 29-member Stakeholder Steering Committee. The goal of the RETI process was to achieve consensus on transmission development for renewable energy sufficient to meet state energy targets. CPAs were identified following a series of environmental and GIS-based exclusions (Figure 2.1). For a full list of excluded lands, see Appendix 2.A (Tables 2.A.1 – 2.A.3). Despite being dated, this dataset was chosen for two reasons: 1) it is still currently being used in the CPUC statewide Integrated Resource Plan modeling, and 2) it included a broader definition and greater overall quantity of developable land in San Diego County than other studies. For example, the renewable energy potential estimates for the Western U.S. from Wu et al 2020[1] were considered but not used, because that study applied more extensive techno-economic and environmental screens, reducing the area and providing very limited options in terms of remaining developable land in San Diego County.

In addition to utility-scale CPAs in non-urban settings, this analysis considers CPAs within urbanized areas, or “infill.” This is defined as undeveloped land in more densely populated areas where small ground-mounted solar arrays could be constructed. The infill CPAs are added from a dataset under development by The Nature Conservancy (TNC) in an update to the 2019

Power of Place (PoP) study.[4] Finally, this report considers the potential capacity and costs for rooftop solar in San Diego using methodology created by Anders and Bialek.[5]

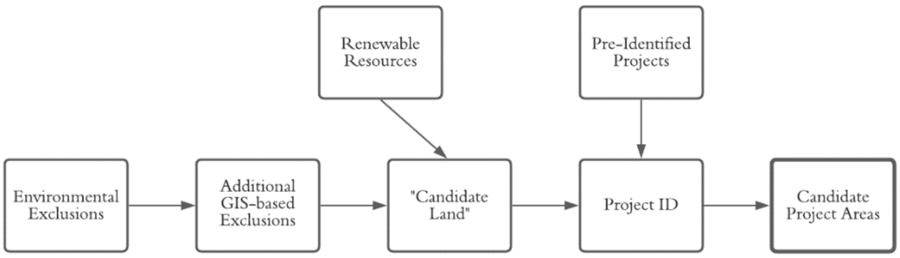


Figure 2.1. RETI CPA delineation Process adapted from the 2009 RETI report.[3]

2.3 Methods

RDF Candidate Project Areas and Downscaling

In order to analyze the spatial distribution and subsequent power capacity of possible renewable energy power generation, we start with all the CPAs in San Diego County and then eliminate areas inappropriate for development (based on a variety of criteria) to identify the most suitable sites. We then calculate how much power generation is possible in these areas. A detailed description of the methods used follows.

For the spatial analysis of low-impact, high-quality areas for renewable electricity development, this analysis uses open-sourced QGIS software to constrain and analyze CPAs within San Diego and Imperial Counties. This section begins with the RETI CPAs in San Diego County and excludes Conserved Lands identified by SANDAG.[6] Lacking these data for Imperial County, this analysis relies on the baseline RETI environmental exclusions (see Appendix 2.A.1 & 2.A.2). All utility-scale CPAs less than one square kilometer (km^2) are excluded as unsuitable for development, where smaller infill solar polygons are retained. Areas of existing and planned solar and wind developments that total 266 Megawatts (MW) are removed (existing sites above 10MW were converted into files created from Google Satellite images and planned sites were digitized from Environmental Impact Report plant maps using the QGIS Georeferencer tool). To divide the CPAs into developable sites, a grid of 4 km^2 for solar and 36 km^2 for wind is overlaid on the sites. Using power density assumption of 30 MW per km^2 (MW/km^2) for solar[7] and 2.7 MW/km^2 for wind,[8] CPAs that produce roughly 100 MW are created, a typical capacity for project modeling.[9–11] Finally, as solar provides higher power density per km^2, for all areas of overlap, solar is prioritized over wind and utility-scale over infill polygons.

The total annual electricity generation for each CPA polygon is identified using the formula below.

$$Power\ density * area * capacity\ factor * 8760\ (hours\ in\ a\ year) = annual\ generation$$

The nameplate capacity, or expected output, is calculated using the power density assumptions stated above. The annual generation in MW hours (MWh) is calculated for each area polygon by first multiplying the hours in a year (8760 hours) and the location-specific capacity factor, or percentage of time when the site is expected to produce electricity. For utility-scale solar, the capacity factor is assumed to be equal to the fixed-tilt solar value in the urban areas, and the tracking value in non-urban areas, where there is more likely to be larger developments on open land suitable for less-dense tracking technology. To identify urban areas, the 2019 US Census Urban areas was used.[12]

This analysis compares the estimated resource potential of renewables with the forecasted electricity demand for San Diego in 2050. Forecasted demand is based on the Central Case of the EER model.[ii] The forecasted demand for Southern California is downscaled to San Diego by applying the percentage of Southern California population in San Diego (13.75%). Next, existing/planned wind and solar generation projects within San Diego County are subtracted from the total forecasted demand to find the amount of new generation capacity needed. Data from the EPA's EIA-860 Form[13] were used to find 470 MW of existing/planned wind and solar capacity. Excluding these 470 MW from the downscaled electricity demand, a balance of 49,979 GWh of electricity generation is found to be needed to achieve a 100% renewable target. Shown in Table 2.1, the total potential utility-scale and infill annual generation from wind and solar CPAs within the County of San Diego is 67,062 GWh, or 17,083 GWh above forecasted demand. Figure 2.2 shows the relative capacities of solar and wind with and without infill compared to the estimated demand. Utility-scale solar resource potential in San Diego County accounts for 98.6% of renewable resources.

[ii] See Appendix A Central Case for model details. Model parameters are available in column "Central" of Table 1; projected installed electricity capacity in California for the Central Case is in Figure 3; 2050 electricity supply in California is in Figure 8.

Table 2.1. Candidate Project Areas in San Diego County.

Findings	*Units*	**Utility-Scale Only**	**With Infill**
Solar Area	sq km	661	843
Wind Area	sq km	86	86
Solar Resource Potential	GWh	54,784	66,332
Wind Resource Potential	GWh	730	730
Total Renewable Resource Potential	GWh	55,514	67,062
Estimated 2050 Electricity Demand	GWh	49,979	49,979
Electricity Resource Balance (assuming no curtailment)	GWh	5,535	17,083

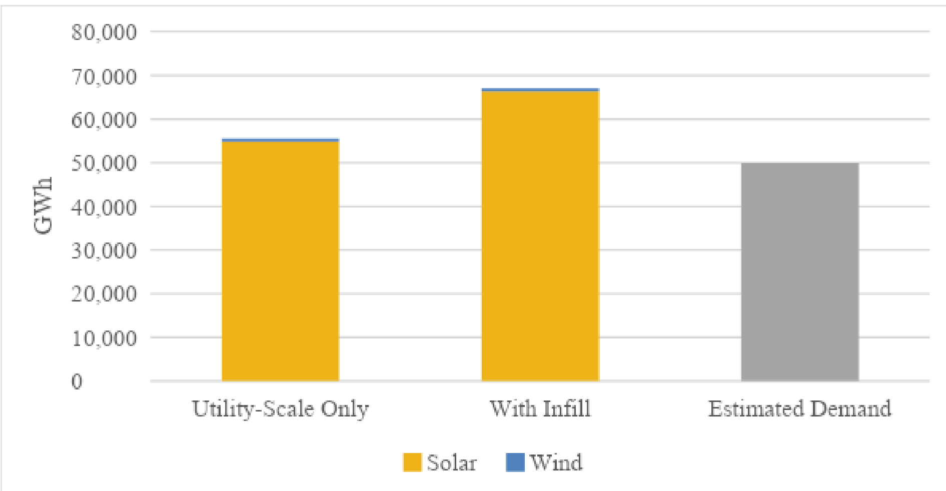


Figure 2.2. San Diego County Renewable Resource Potential. Notes: The total resource potential within San Diego County for utility-scale and utility-scale with infill is shown relative to the estimated 2050 electricity demand (grey) based on the downscaled Central Case scenario of the EER model for 2050 detailed in Appendix A. The bars show that the resource potential exceeds demand in both cases of utility-scale only and utility-scale with infill. Both the demand and resource potential account for existing resources within San Diego County.

To arrive at an estimate of the wholesale cost of electricity for utility-scale CPAs, the levelized cost of energy (LCOE), or the adjusted cost of electricity production per MWh, is calculated. Calculations begin by adding the solar and wind plant capital cost and the costs of interconnection to the grid. The plant capital cost is based on a capital expenditure cost assumption for utility-scale solar (1,599 $/kW) and wind (1,556 $/kW) from NREL.[14] The interconnection cost is based on the distance to the nearest substation and a transmission cost assumption of 2,948 $/MW-mile from the NREL ReDS model.[15] In these calculations, a substation dataset from DHS[16] is used and the Euclidean distance to the nearest substation is calculated to approximate the interconnection distance. The estimation of annual payments is based on a capital recovery factor of 7.36%.[17] The LCOE is then calculated using the formula below to find the ratio of payments to generation, or the wholesale cost per MWh of electricity.

$$\frac{(capital + interconnection) * capital\ recovery\ factor}{annual\ generation} = Levelized\ cost\ of\ energy$$

For infill solar development, the PoP CPAs and the annual generation formula above are used. To calculate the LCOE, this analysis uses the average of large and small non-residential capital cost of 2.7 $/W for solar installation from Berkeley Lab's Tracking the Sun Report as the capital cost.[18] There is no interconnection cost, as it is assumed to be included in the LBNL capital cost. The same capital recovery factor of 7.36% is applied and the LCOE is calculated using the formula below.

$$\frac{capital * capital\ recovery\ factor}{annual\ generation} = Levelized\ cost\ of\ energy$$

The range of LCOE across both infill and utility-scale CPAs in San Diego County is shown in Figures 2.3 (solar) and 2.4 (wind). Figure 2.5 shows the CPAs across San Diego and neighboring Imperial County. Note that the cost of balancing resources are not included in solar and wind capital cost estimates. For grid reliability in the deeply decarbonized scenarios described here, balancing resources beyond wind and solar would be needed. Options include energy storage, retention of gas peaker plants, increased interregional coordination for geographic diversity of power generation resources, and other options described in the EER modeling. Costs of balancing resources vary widely, and have significant uncertainty, and should be further explored in future work to complement this spatial analysis.

Site Selection Scenarios

Next, renewable energy sites need to be chosen and their development sequenced starting with least cost. To sequence the CPAs needed to achieve 100% renewable energy by 2050, 10-year timesteps are used from the EER Central Case estimated demand forecast for San Diego starting in 2030.[iii] A site selection algorithm modeled after Wu et al.[1] is implemented. The algorithm is run on two scenarios:

> **Site Selection Scenario 1**: San Diego-Only (solar and wind resources within San Diego County)
> **Site Selection Scenario 2**: San Diego and Imperial County Scenario (solar, wind, and geothermal resources within San Diego and Imperial Counties, with transfer of power between the two assumed)

[iii] See Appendix A for model details and electricity forecasts.

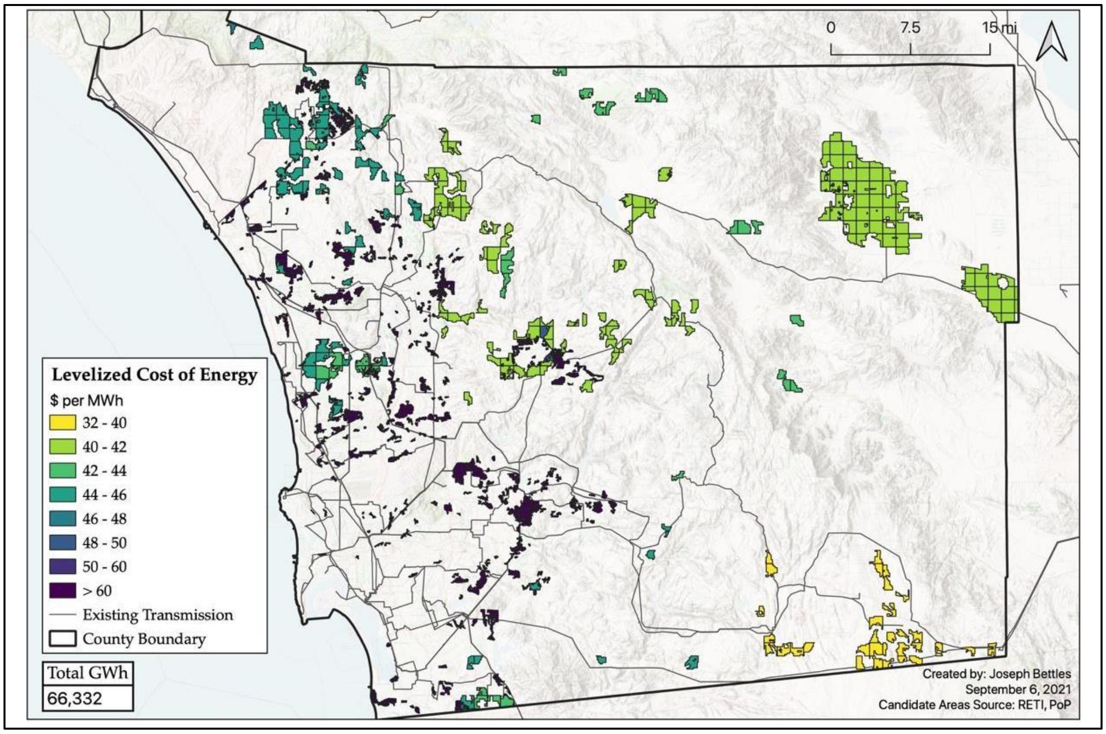


Figure 2.3. Solar Candidate Project Areas in San Diego County and the LCOE per CPA.

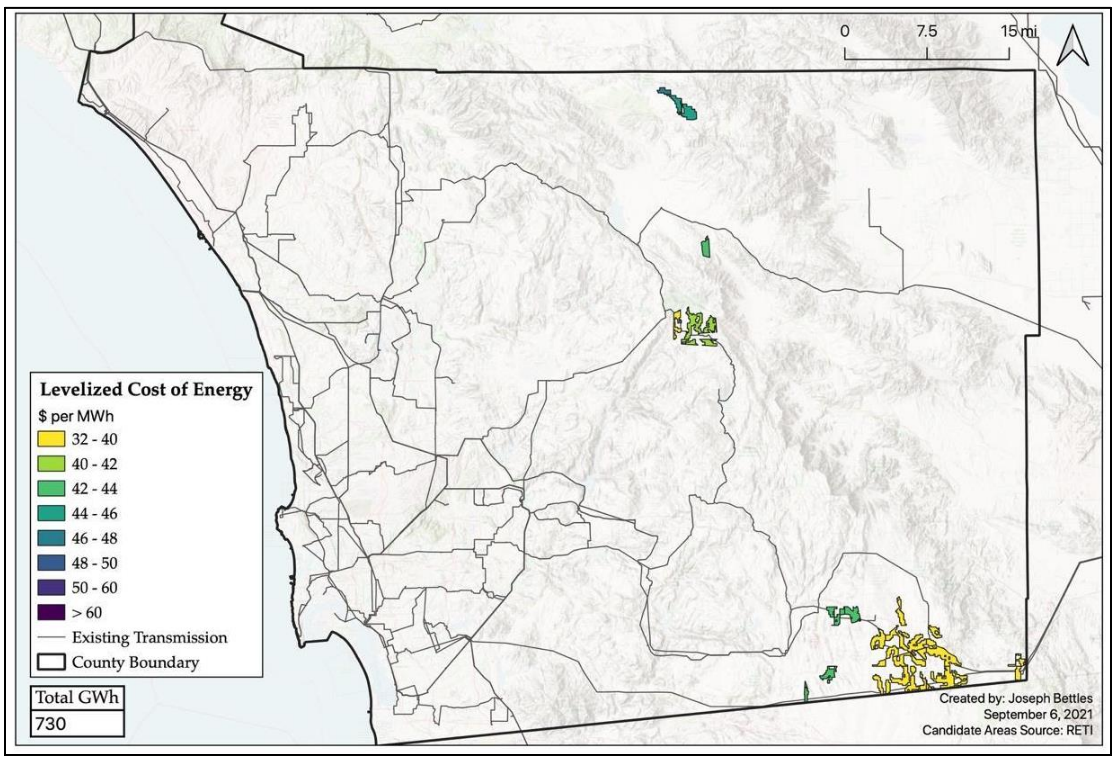


Figure 2.4. Wind Candidate Project Areas in San Diego County and the LCOE per CPA.

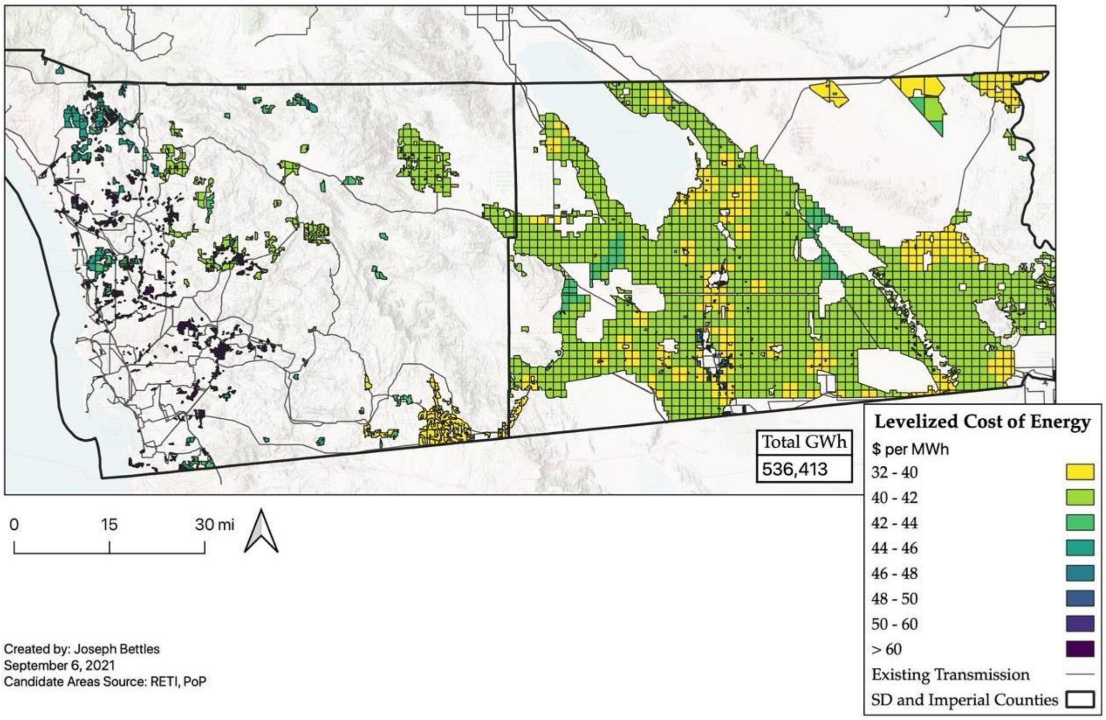


Figure 2.5. Solar and wind Candidate Project Areas in San Diego and Imperial Counties. Notes: Areas suitable for wind and solar development within San Diego County are shown in Figures 2.3 and 2.4 and within San Diego and Imperial County in Figure 2.5. The maps show the levelized cost of energy (LCOE), with the least cost in yellow. Utility-scale CPAs are from the RETI dataset and infill solar CPAs are from the 2019 PoP dataset. The LCOE is calculated based on capacity for each area polygon, capital costs, interconnection costs, and a capital recovery factor. Existing transmission lines are also pictured in Figures 2.3-2.5.

Unlike wind and solar CPAs, geothermal resource potential is confined to select sites with known resources. Therefore, for the San Diego and Imperial Scenario, the E3 and CPUC statewide Integrated Resource Plan (R-20-05-003) estimated supply of geothermal in neighboring Imperial County is used (no geothermal sites have been identified in San Diego County).[19] Five geothermal sites are identified in Imperial County with generation of 10,680 GWh of electricity (seen as green points in Figure 2.8). This analysis assumes these plants become fully operational by 2030 and supply the remaining capacity to San Diego after satisfying Imperial County's electricity demand. The total geothermal generation available for San Diego is downscaled by multiplying the proportion of residents in the County of San Diego to the overall population of the two counties (94.7%). We therefore assume, for the purposes of this model, that 10,113 GWh of geothermal firm power from Imperial County will go to San Diego County. In the San Diego and Imperial Scenario, 10,113 GWh is subtracted from all three time steps of the forecasted electricity demand.

Candidate Project Area (CPA) Scenarios

In addition to the site selection scenarios, alternate scenarios to select CPAs are analyzed that factor in four new exclusion zones based on different policy goals: 1) minimize environmental impact, 2) avoid high-pecuniary value land, 3) maximize carbon sequestration potential, 4) include only developable land as identified by SANDAG. For each scenario the methodology described in section 3.1 is used to identify the LCOE and available capacity of CPAs under more restrictive scenarios within the boundaries of San Diego County.

CPA Scenario 1: Low Environmental Impact

To show renewable site selection under a scenario in which avoiding high environmental impact is highly prioritized, the most restrictive siting level areas for wind and solar resource potential areas in the West are used (Unconstrained SL 4) from the Wu et al.[1] study of low-impact renewable energy siting. The study incorporated high-resolution ecological and agricultural datasets to identify sites with low impact on the environment. In this scenario all urban infill CPAs are included because of lower environmental impacts from siting in urban areas.

CPA Scenario 2: Reduce Loss of Land with High Pecuniary Value

To identify CPAs that factor in the pecuniary value of land, the Cropland Data Layer raster from the US Department of Agriculture is used.[20] To analyze the raster with the CPA sites, the zonal statistics tool is run on a 0.10 km^2 grid to identify the modal land use within each cell. To restrict the CPAs to land with low pecuniary value, the data is filtered to include only "Fallow/Idle Cropland", "Grassland/Pasture", "Forest", "Wetland", "Shrubland", and "Barren." Urban infill is excluded in this scenario because of the higher relative value of land in the urban environment.

CPA Scenario 3: Reduce Loss of Land with High Carbon Sequestration Potential

In the third scenario, lands which have high carbon sequestration potential are excluded. Analysis from Chapter 4 is used, which identifies carbon pools within San Diego County. SANDAG's Vegetation Dataset is also used, which classifies the vegetation types in the County.[21] The data is filtered to vegetation with high CO_2 Sequestration potential (see Appendix 2.C for a full list). These lands are excluded from the renewable resource potential to find CPAs under a scenario that prioritizes natural carbon sequestration. Urban infill sites are included in this scenario because of the lower carbon sequestration potential of infill land.

CPA Scenario 4: Restrict Sites to Developable Land

The fourth scenario identifies potential sites that exist on developable land, given that they are likely to face fewer legal and social barriers. SANDAG's Developable Land data is utilized, which classifies “Vacant” and “Agricultural Redevelopment” as suitable for development.[22] In this scenario, urban infill sites are excluded as having higher barriers to development.

CPA Scenario 5: Prioritize investments in frontline communities
The fifth scenario includes prioritizing rooftop solar and urban infill solar, in particular in communities where the economic development, good-paying local jobs, and potential air quality benefit, reducing emissions from local thermal plants, would have high societal value.

The Climate Equity Index (CEI) was created for the City of San Diego in 2019 and updated in 2020 through a stakeholder process to address environmental justice and social equity.[23] The CEI measures access to opportunity at the census tract level through 35 indicators covering health, housing, socioeconomic, mobility, and environmental categories. As with the SB 535 Disadvantaged Community designation, the communities that score as having “low access” are primarily in the southern areas of San Diego including Barrio Logan, Lincoln Park, Mountainview, and the Tijuana River Valley.[24]

SANDAG has identified communities of concern and has stated a goal to ensure that Low Income and Minority communities receive benefit from public investments, in particular transportation and mobility investments These county-designated Communities of Concern are spatially distributed throughout the county.[25] The highest concentration occurs in the coastal southwest part of the County.

The communities in the southwest part of the County (National City, Chula Vista, and San Ysidro, for example) are also designated Disadvantaged Communities (DAC) by the state (Figure 2.6). DACs are identified by CalEPA to be disproportionately burdened by and vulnerable to multiple sources of pollution.[26] Under California state law (SB 535 and AB 1550), DACs are specifically targeted for investment of proceeds from the State's cap-and-trade program. Known as California Climate Investments (CCI),[27] these funds are aimed at improving public health, quality of life, and economic opportunity in California's most burdened communities at the same time they are reducing pollution that causes climate change.

A scenario maximizing rooftop and urban infill solar and energy storage in these frontline communities could result in 5-30% reduction in infrastructure development on previously undisturbed land (greenfield development). It could also have multiple co-benefits, including progress toward county-level and higher-level equity goals, job creation in “green job” or “cleantech” sectors with corresponding well-paying wages,[iv] reduced GHG emissions and

[iv] San Diego’s jobs in these industry groups grew 17.6% from 2010 to 2018. https://www.sandiego.gov/sustainability/social-equity-and-job-creation

criteria pollutants from land use change for energy infrastructure, and availability of supplemental funding sources for example from the state. Further study to quantify the local economic and public health benefits of such a scenario would be valuable; however, adequate information exists[28] to support early action to pursue growth in rooftop solar, especially in communities overly burdened with pollution and having low access to opportunities.

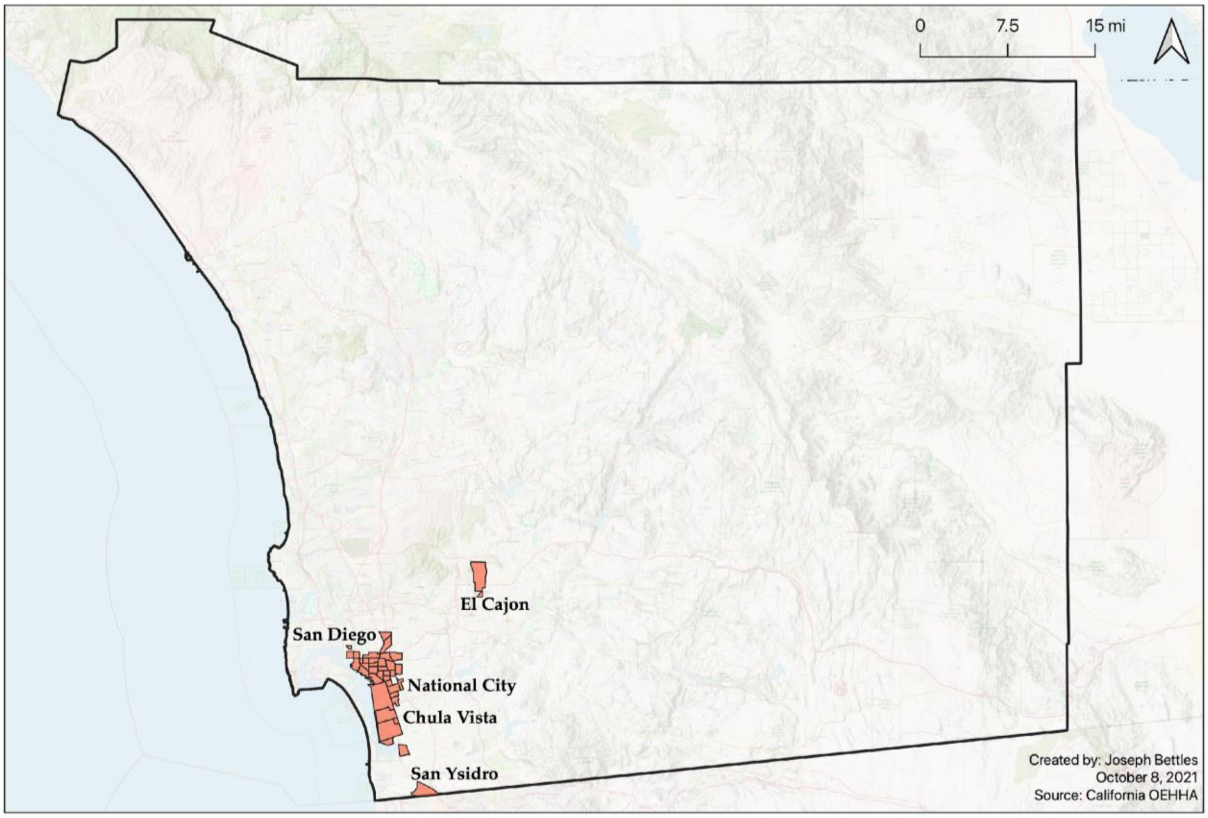


Figure 2.6. Disadvantaged Communities in San Diego County.

Infill and Rooftop Solar Scenario Capacity and Costs

In a 2003 analysis by Anders and Bialek,[5] the GIS analysis of non-residential rooftops in the City of San Diego identified approximately 143,489,645 square feet (3,294 acres) of usable roof area. The ratio of total usable roof area to total developed land was identified as [3,294 acres of total usable area]/[26,078 acres of total developed land] = 12.6%. This study assumes that all other jurisdictions in the San Diego region would have a similar ratio of total developed land to usable roof area. This ratio was applied to the jurisdictions outside the City of San Diego to derive an estimated technical potential for the remaining portions of the County of San Diego. This resulted in a total estimated county-wide capacity of approximately 1,726 MW AC.[5]

A more recent solar siting survey by Clean Coalition identified the 2018 non-residential solar rooftop potential in the City of San Diego at 499 MW. The Clean Coalition analysis incorporates additional information about how much distributed generation could be accommodated on specific electric distribution system circuits in the City of San Diego, based on Integration Capacity Analysis (ICA) data from SDG&E. However, the geographic extent of this analysis includes the City of San Diego only, not other cities, or the unincorporated county. Using a simple extrapolation, assuming that the city-to-county ratio remains 44% (769 MW in the City, compared to 1726 MW county-wide, as characterized by Anders and Bialek, 2003[5]), then the countywide non-residential rooftop potential would be 1,134 MW, based on extrapolation of the 499 MW city value.[29] At an assumed 28% capacity factor,[30] this corresponds to 2,781 GWh annual generation county-wide. This is 5.5% of estimated 2050 electricity demand. At an average LCOE of $92/MWh, these non-residential solar systems are estimated to be on the high end of candidate project costs (see Figure 2.3 for comparison).

This value is based on existing buildings only, and the rooftop resource potential would increase if it were updated to include anticipated new buildings in 2050. Future analyses should estimate the 2050 rooftop solar potential, using the SANDAG 2050 forecasted footprint of developed land. Relevant GIS data are available through the SANGIS portal (see Planned Land Use for the Series 13 Regional Growth Forecast (2050)). At a high level, urban land in the U.S. is expected to grow by 1-4 times by 2100, thereby increasing the anticipated rooftop solar potential.[31]

Future analyses should also perform a detailed Integration Capacity Analysis (ICA), expanding beyond the City of San Diego to include other jurisdictions throughout the County of San Diego, to confirm distribution grid capability to accommodate these resources.

Least-cost Near-term Scenario

To identify a least-cost scenario for near-term action, this analysis looks for CPAs within San Diego County which are the lowest cost in both the San Diego-only and San Diego and Imperial site selection scenarios. The sites selected in both scenarios are identified to meet the forecasted 2025 electricity demand. Then the 2025 outputs from the two scenarios are intersected in QGIS to find the CPAs identified in both as a least-cost scenario.

2.4 Results and Discussion

Site Selection Scenarios

The results of the site selection scenarios are shown in Figures 2.7 & 2.8 below. In the San Diego-only Scenario (Figure 2.7) the 2030 sites are selected based on LCOE clusters largely around Jacumba Hot Springs in the Southeast and Borrego Springs in the Northeast parts of unincorporated San Diego. In the 2040 and 2050 time-steps, CPAs closer to urban areas are selected. Few urban infill CPAs are selected in the San Diego scenario as the LCOE is relatively higher due to lower capacity factors, in part from the restriction of fixed-tilt installations. The San Diego-only scenario also requires higher overall electricity generation from renewable resources due to the lack of geothermal resources from Imperial County. The lack of firm power would also increase the requirement for additional generation and storage capacity for reliance on intermittent resources, which would likely add, possibly substantially, to the cost. Battery energy storage and pumped hydro could be deployed to meet this need.

In the San Diego and Imperial Scenario (Figure 2.8) geothermal and solar resources from Imperial County are factored into the resource potential to meet 100% of San Diego's electricity demand. While the area east of Jacumba Hot Springs remains a priority cluster for solar and wind development within the County of San Diego, most other CPAs from the San Diego-only Scenario are not selected as the costs are higher than resources from Imperial County. Geothermal resources (green points) reduce the overall requirement for wind and solar resources. Also, a larger geographic area of resource aggregation may also reduce the overcapacity and storage needed to balance supply and demand because of the geographic diversity of wind and solar generation profiles, thereby increasing reliability and reducing system costs. In the San Diego and Imperial Scenario, no infill resources are selected due to lower-cost sites in Imperial County.

Though the scenarios explored so far can likely generate enough energy on a GWh basis to meet forecasted demand, the mismatch between the timing of renewable generation (supply) and electric loads (demand) across days and seasons means that these identified GWh will not be able to meet real-time demand alone. In a study of the ability of high-renewable (80%+) systems to reliably meet demand across the US, Shaner et al.[32] found that a system with 75% solar and 25% wind generation could achieve 98.74% reliability (aggregated over a geographic area roughly the size of the continental US) or 90-95% reliability (if aggregated over an area roughly the size of San Diego and Imperial counties combined), as long as 50% excess generation (~25,000 GWh) plus storage equal to 12 hours of mean demand (in MW) were included. This is a lower bound for what will be necessary in practice, since the reliability standard set by the North American Electricity Reliability Corporation (NERC) is 99.97%.

In order to approach 100% reliance on zero carbon resources, this large reliability gap must be filled by some combination of excess intermittent generation, long and short duration storage, clean dispatchable power generation, and demand-side management (such as conservation during periods of peak demand). Decisions about which resources to choose will depend on the status, cost, and negative impacts of existing and new technologies and the willingness of end users to adapt their energy use to smooth demand peaks. The 2020-2021 CAISO Transmission

Planning modeling (base case) included 300 MW pumped hydro storage at San Vicente as well as 660 MW of 4-hr battery energy storage in San Diego County.[30] Together, these planned energy storage resources make up about 20% of the anticipated need.[v] Other options could include overbuilding the renewable CPAs, with curtailment as a cost-effective tool to deliver more renewable energy through existing transmission lines. A 2017 study found that allowing 10% annual solar curtailment enables a 5-fold increase in the amount of annual solar generation that can be delivered on existing transmission lines.[33] Additional options include natural gas-fired generation with carbon capture and storage, other zero carbon gaseous fuels such as hydrogen from electrolysis, or rapid scale-up of demand response programs in the region, among others. Given the rapidly changing nature of technology and the fact that human behavior related to demand-side management is not well understood, the optimal combination for ensuring reliability is currently unknown and unknowable.

In both site selection scenarios, the increased electricity demand for the region due to electrification as shown in the EER model may require transmission upgrades to avoid higher costs[34] and curtailment of renewable resources.[35] Increased transmission capacity may also enable greater reliability due to interconnection with more geographically diverse hourly generation profiles that smooth out variable power generation.[32]

Table 2.2 lists the costs and timelines of the six identified major transmission upgrades for the region from an analysis by the California Independent System Operator (CAISO).[36] These are transmission upgrade *options* only. Statewide modeling results have not yet been released, indicating which (if any) of these options will be needed or will be optimal. While transmission upgrades will be overseen by state agencies and the local utility, the process will interact with local communities where new transmission upgrades are sited. The planning process for these six transmission upgrades is still underway. These are transmission upgrades that have been studied by the CAISO, and they are upgrade options in state-level modeling for the state's Integrated Resource Plan (IRP). In the IRP proceeding, a statewide 2030 portfolio with high penetration of renewables is modeled, and least-cost transmission upgrades are selected from this list of options, to support and enable transmission planning for the state's clean energy and climate goals. The updated "Modeling Assumptions for CAISO 2022-2023 Transmission Planning Process" will be released in Q4 2021,[vi] and this report will shed light on which transmission

---

[v] Assuming that mean demand (in MW) can be calculated as 2050 electricity consumption forecast divided by the total number of hours per year (49,979,000 MWh / 8760 hrs-per-yr = 5,705 MW mean demand).

[vi] For example from a previous year, see CPUC report "Modeling Assumptions for 2021-2022 Transmission Planning Process." https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-power-procurement/long-term-procurement-planning/2019-20-irp-events-and-materials/portfolios-and-modeling-assumptions-for-the-2021-2022-transmission-planning-process

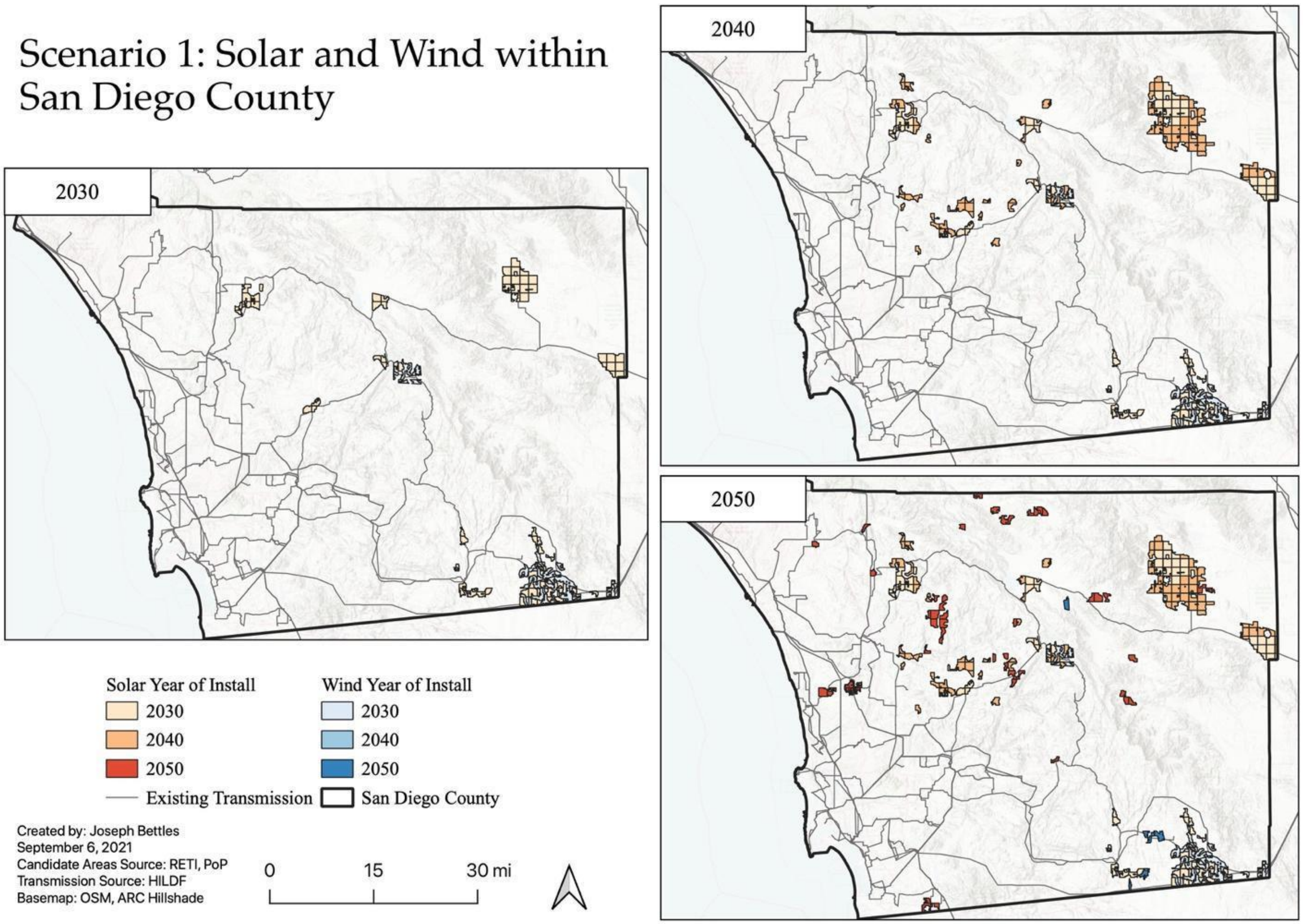


Figure 2.7. Site Selection Scenario: San Diego County Only.

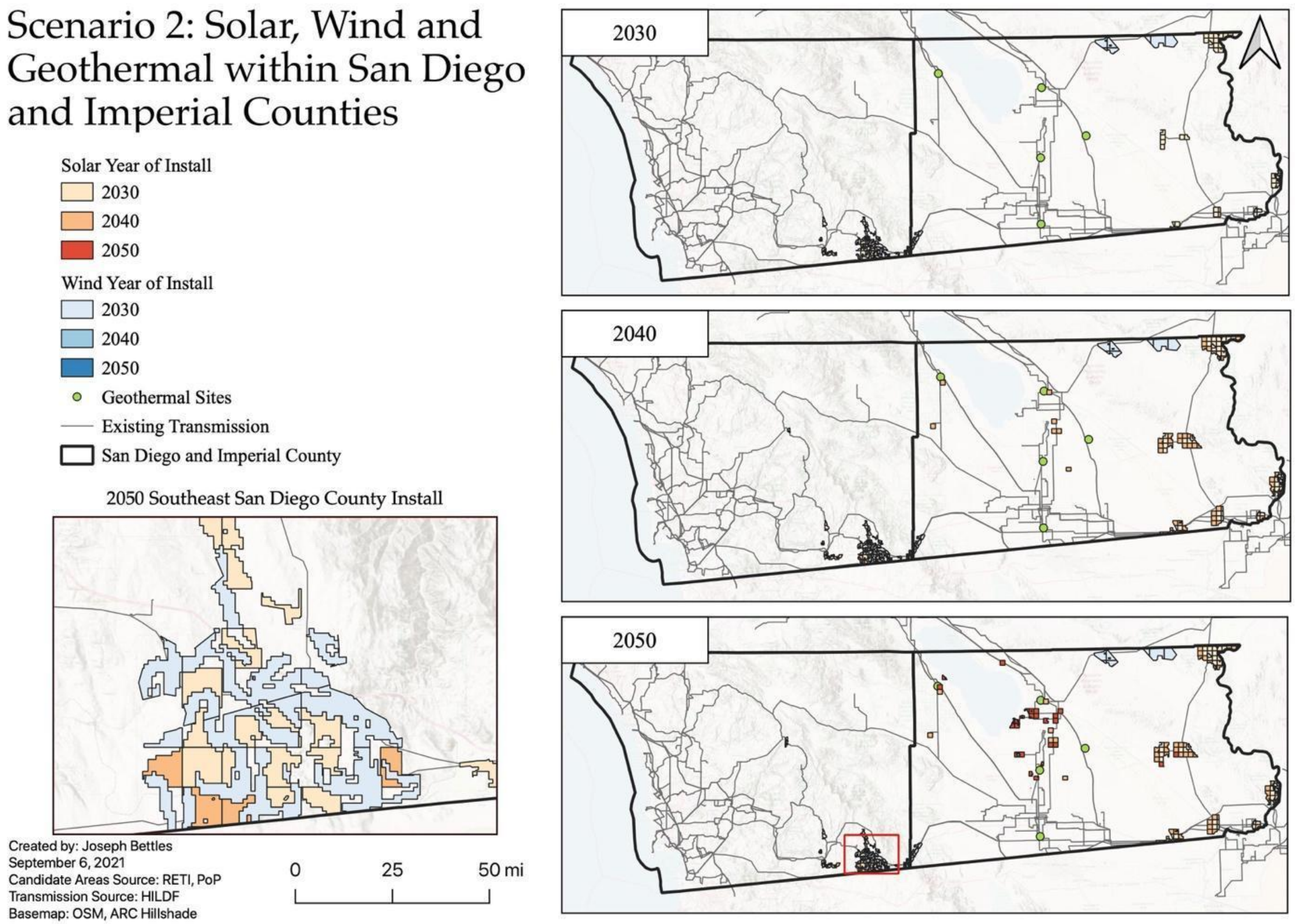


Figure 2.8. Site Selection Scenario: San Diego and Imperial Counties.

Table 2.2. Transmission upgrades and costs In the SDG&E territory. Data from an analysis by the CAISO.[37]

Transmission Constraint	Affected Zones	Estimated Full Capacity Deliverability Status Based on On-Peak Study Resource Output		Area Delivery Network Upgrades (ADNU) & Cost Estimate			Wind/Solar Area Designation
		Existing System (MW)	Increase due to ADNU (MW)	ADNU	Construction Time (months)	Cost ($millions)	
East of Miguel Constraint	Arizona, Imperial, Baja, Riverside	731	1,412	New Imperial Valley - Serrano 500 kV line	120	$3,680	Solar
Encina-San Luis Rey Constraint	Arizona, Imperial, Baja, Non-CREZ within San Diego	2,901	3,718	New Encina - San Luis Rey 230 kV line	120	$102	Solar
Imperial Valley transformer Constraint	Imperial	1,959	400	New Imperial Valley 500/230 kV Bank at new substation	105	$214	Solar
San Luis Rey-San Onofre Constraint	Arizona, Imperial, Baja, Non-CREZ within San Diego	1,748	4,269	New San Luis Rey-San Onofre 230 kV line	120	$237	Solar
San Diego Internal Constraint	Imperial, Non-CREZ within San Diego	968	2,067	Internal San Diego reconductoring	18	$89	Solar
Silvergate-Bay Boulevard Constraint	Imperial, Baja, Non-CREZ within San Diego	1,202	2,119	Silvergate - Bay Blvd 230kV 3-ohm Series Reactor	72	$31	Wind
San Diego Oceanside Constraint	Non-CREZ within San Diego	280	301	Oceanside ADNU	60	$133	Solar
Total (MW)		9,058	12,874		**Total Cost**		$ 4,486
Total Additional (MW)			**3,816**		**Cost per additional MW**		$ 1,175,577

upgrades are selected in IRP modeling. However, the timeframe of that study ends in 2030, and further upgrades are likely to be needed in the 2050 timeframe. The CAISO is separately undertaking a 20-yr transmission outlook study process,[37] and clean energy planning efforts in the San Diego region should incorporate findings from the CAISO 20-yr transmission outlook study as they come available.

Candidate Project Areas Scenarios

As policymakers consider alternate scenarios for siting renewable resources, priorities beyond the wholesale cost of energy may factor into the decision making. Figures 2.9 through 2.12 show solar and wind CPAs under four policy scenarios within the County of San Diego. Table 2.3 shows a summary of the resource potential for each scenario.

CPA Scenario 1: Low Environmental Impact

When more environmental screens are applied to identify low-impact CPAs as in Wu et al.,[1] the resource potential is reduced by 76.5%. Most remaining CPAs are in the urban infill, which was included without further restriction from the previous analysis. The remaining total resource potential is 15,777 GWh, requiring imports to approach 100% of electricity demand.

CPA Scenario 2: Restrict Land with High Pecuniary Value

The exclusion of land with high-pecuniary value does not significantly lower the capacity of utility-scale renewable generation within San Diego County. Most of the land identified in the previous scenarios was not on high-value cropland. The resulting total resource potential is 52,394 GWh. Therefore, if 95.4% of the resource potential on land with low value is developed, San Diego County would be able to approach 100% of electricity demands with resources internal to the County.

CPA Scenario 3: Restrict Land with High Carbon Sequestration Potential

When CPAs are restricted by removing land with high carbon sequestration potential, the resulting capacity is 22,844 GWh, or roughly one-third the original capacity. Much of the remaining CPAs are in the urban infill which are included without further restrictions in this scenario. In this scenario, the County would require imports to approach 100% of electricity demand with renewable energy.

CPA Scenario 4: Restrict Sites to Developable Land

Restriction of CPAs to developable land may provide decision makers with low-hanging fruit in terms of ease of development. When CPAs are restricted to “Vacant” and “Agricultural Redevelopment” land types, there is 13,894 GWh of remaining resource potential. This is not enough to fulfill the County's electricity demand internally, but it provides a good starting point for near-term resource development at 28%.

Table 2.3. CPA scenarios resource potential and deficit with projected demand summary.

Scenario	*Resource Potential (GWh)*	*Deficit with Demand*
Low Environmental Impact	15,777	-34,202
Low Land Value	52,394	2,415
Carbon Sequestration Potential	22,844	-27,135
Developable	13,894	-36,085

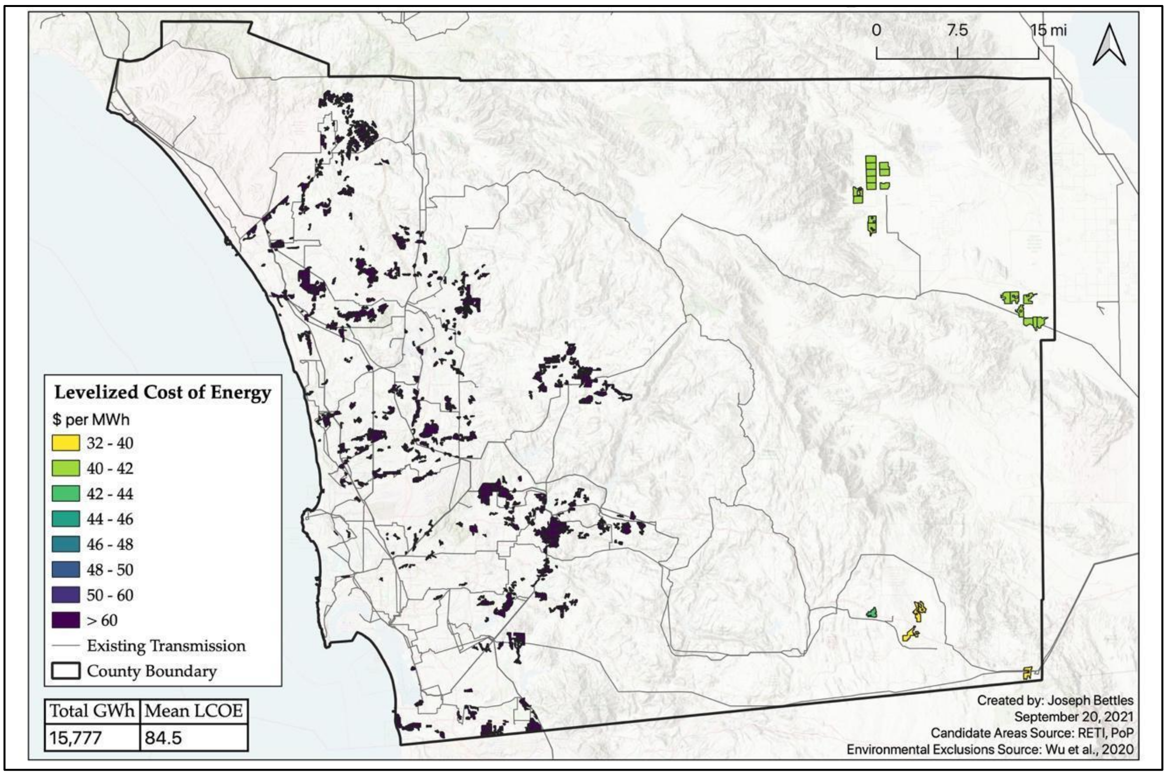


Figure 2.9. CPA Scenario 1: Low Environmental Impact.

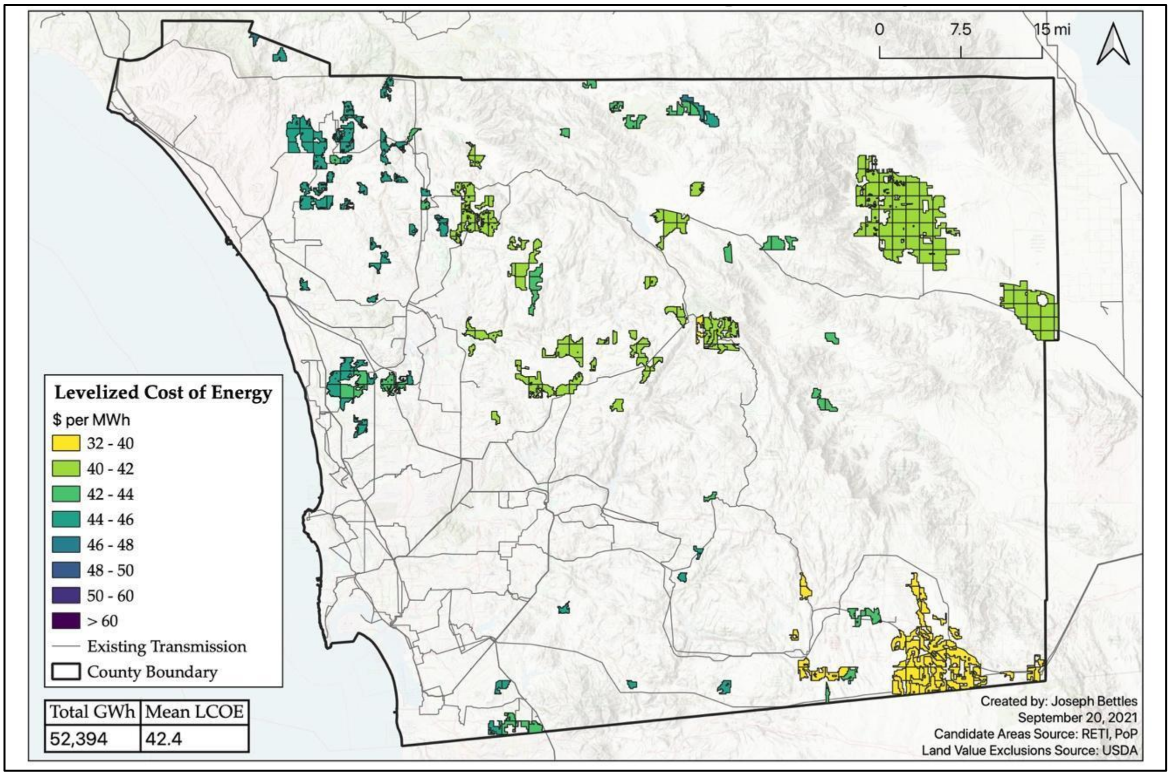


Figure 2.10. CPA Scenario 2: Restrict Land with High Pecuniary Value.

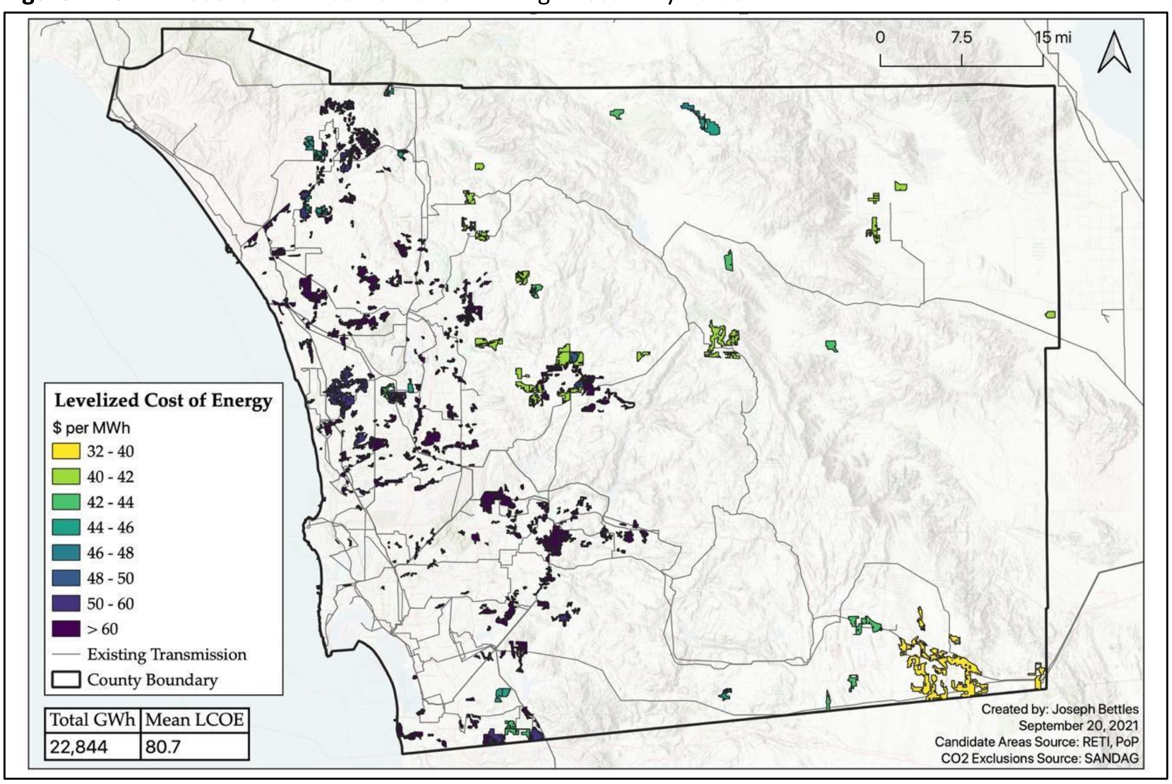


Figure 2.11. CPA Scenario 3: Restrict Land with High Carbon Sequestration Potential.

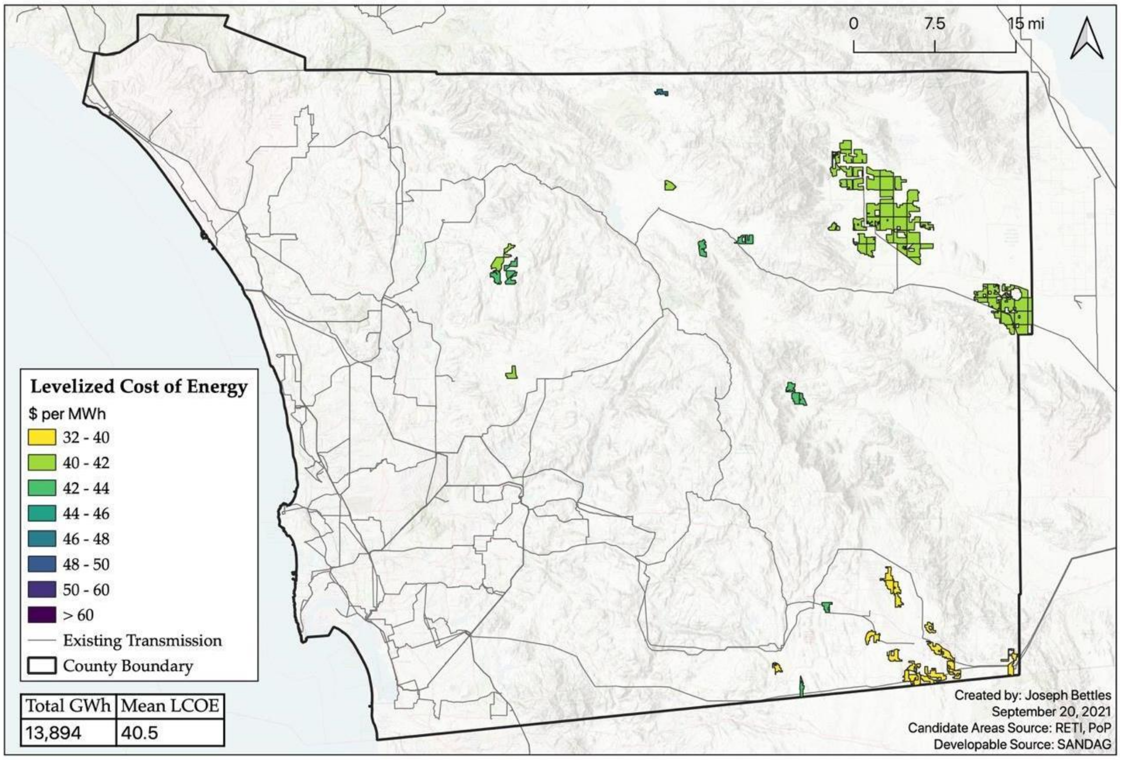


Figure 2.12. CPA Scenario 4: Restrict Sites to Developable Land.

Infill and Rooftop Solar Costs

Results of the rooftop solar analysis are summarized in Table 2.4 below. This analysis is not intended to make any indication of reliability. It is only intended to show cost-ranked ordering of renewable resource options. This illustrates why most planning efforts don't rely more heavily on rooftop solar, despite strong stakeholder interest in rooftop solar's co-benefits. Rooftop solar has much higher capital costs than ground-mounted solar and other renewable options. Studies show that an optimal portfolio can be designed to include higher rooftop solar penetration, and a higher-rooftop-solar-portfolio can also maximize co-benefits, while achieving the same societal cost of the overall portfolio (with the caveat that societal cost is defined differently than simple capital cost of the generating equipment).[39]

Table 2.4. Cost Scenarios of Rooftop and Solar.

Cost Scenarios	*Average LCOE ($/MWh)*	*Total GWh in San Diego County*	*Percent of Demand*
Average US Combined Cycle Natural Gas Plant[38]	34.51	N/A	N/A
Output of Scenario 1 (Sites selected based on LCOE)	40.65	49,979	100%
Rooftop Solar	92.32	2,781	5.6%
Rooftop and Infill Solar	70.04	15,100	30.2%

Least-cost Scenario

The least-cost scenario shown in Figure 2.13 provides an estimate of the lowest cost wind and solar resources that were selected in both site selection scenarios (San Diego-only and San Diego/Imperial) for 2025. Shown in Table 2.5, the total resource capacity in this near-term scenario is 4,107 GWh or 8.2% of the total 2050 electricity demand. These sites represent low-cost CPAs in San Diego County regardless of whether the region imports power (and whether necessary transmission upgrades occur). As shown in Figure 2.13, the least-cost CPAs are located adjacent to the recently approved JVR solar PV site near Jacumba Hot Springs.[40] The development of this project signals commercial interest in renewable siting in this part of the County that reinforces this area as an economically attractive site for development. It should be noted that the algorithm selected wind as well as solar because of the low LCOE. However, per square kilometer, the energy density of wind is 9% of solar PV. As a more energy dense resource, solar may be the more favorable technology in a least-cost scenario. There are, however, some indications of greater societal preferences for wind.[41,42] There is general agreement in the modeling and planning communities that more wind on the system is desirable, from a resource-diversity perspective; however high-quality wind resources are relatively scarce in California.

Table 2.5. Summary of near-term least-cost site selection.

Least-cost Summary

2050 Demand (GWh)	49,979
Least-Cost Generation (GWh)	4,107
Percent of Total Demand	8%

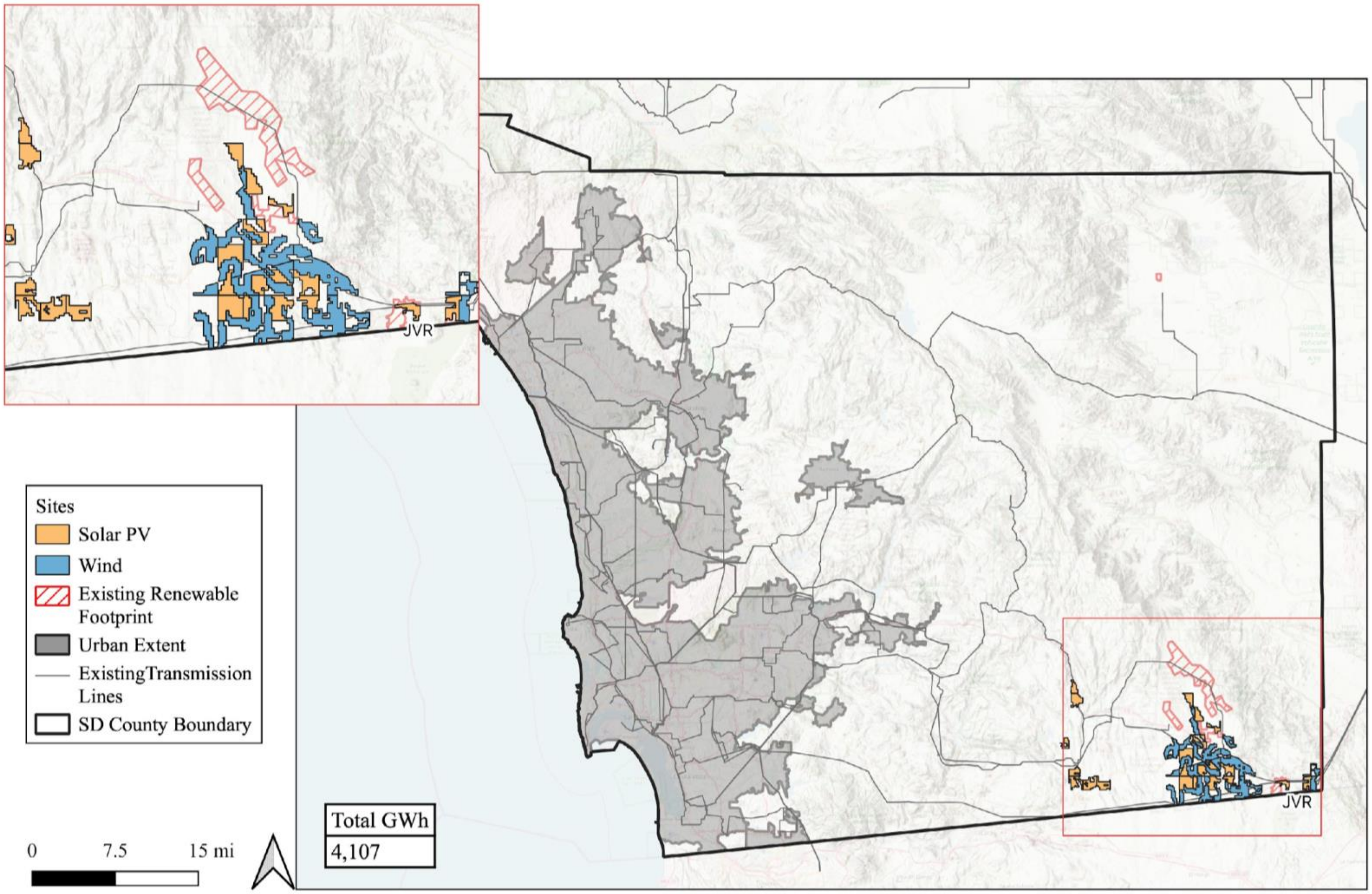


Figure 2.13. Least-cost Scenario for 2025. Notes: The least-cost scenario shows sites that were selected to meet the 2025 electricity demand in both the San Diego-only and the San Diego and Imperial Scenarios. They are the lowest cost CPAs regardless of whether electricity is imported from Imperial County. The sites center around the Jacumba Hot Springs in the southeast part of the County. They are located near existing and planned renewable sites, including the JVR site approved by the Board of Supervisors in 2021.

2.5 Conclusion

To develop the necessary renewable resources that approach 100% of electricity demand by 2045, San Diego will need to engage in near- and long-term planning to ensure priorities such as environmental protection, cost, carbon sequestration potential, equity, and land value are considered adequately in deployment. This report has shown that balancing these priorities may be possible with available resources in the region.

Transmission upgrades may be needed to avoid congestion. There are opportunities for power transfer between San Diego and Imperial Counties, including solar and geothermal firm power which can increase reliability. Given the necessary expansion of the electricity supply to meet estimated ~50,000 GWh of demand (or ~5,700 MW of capacity) by 2050, there will need to be more than two new operational 100 MW clean power plants every year between now and 2050 that supply electricity to San Diego County. If the timeline is constrained to 2035, this would require more than four new operational 100 MW clean power plants every year. Close coordination with state agencies such as the CAISO and the CPUC can help accelerate the deployment of clean energy infrastructure, including transmission.

A scenario maximizing rooftop and urban infill solar and energy storage in frontline communities could result in 5-30% reduction in infrastructure development on previously undisturbed land (greenfield development). It could also have multiple co-benefits, including progress toward county-level and higher-level equity goals, job creation in "green job" or "cleantech" sectors with corresponding well-paying wages,[vii] reduced GHG emissions from land use change for energy infrastructure, and availability of supplemental funding sources from sources such as the state. If coupled with apprenticeship programs, job training opportunities could be significant. Further study to quantify the local economic and public health benefits of such a scenario would be valuable; however, adequate information exists to support early action to promote growth in rooftop solar, especially in communities overly burdened with pollution and having low access to opportunities.

In all scenarios, such high reliance on intermittent renewables implies a need for reliability studies to quantify how much additional long and short duration energy storage, clean dispatchable power, and demand-side management may be needed. Given that the best combination of these is currently highly uncertain, local leaders must engage in a concerted effort--executed in parallel with rapid renewable deployment--to learn about and deploy the

---

[vii] San Diego's jobs in these industry groups grew 17.6% from 2010 to 2018. https://www.sandiego.gov/sustainability/social-equity-and-job-creation

best options for ensuring reliability. This could include coordination with the CPUC Integrated Resource Planning team and Resource Adequacy team, and with the CAISO Local Capacity Requirement (LCR) and Transmission Planning Process (TPP) teams to ensure that renewable energy development in the region is compatible with San Diego Local Capacity Requirements and reliability needs. Additional coordination with federal agencies and academia could be beneficial to identify and adopt the best strategies while abandoning those strategies that do not work.

Works Cited

1. Wu, G. C., Leslie, E., Sawyerr, O., Cameron, D. R., Brand, E., Cohen, B., Allen, D., Ochoa, M., & Olson, A. (2020). Low-impact land use pathways to deep decarbonization of electricity. *Environmental Research Letters*, *15*(7), 074044. https://doi.org/10.1088/1748-9326/ab87d1
2. Zichella, C., & Hladik, J. (2013). Siting: Finding a Home for Renewable Energy and Transmission. *The Electricity Journal*, *26*(8), 125–138. https://doi.org/10.1016/j.tej.2013.09.001
3. RETI. (2009). *Renewable Energy Transmission Initiative Phase 2a Final Report* (RETI-1000-2009-001-F). RETI Coordinating Committee.
4. Wu, G. C., Leslie, E., Allen, D., Sawyerr, O., Richard, D., Brand, E., Cohen, B., Ochoa, M., & Olson, A. (2019). Power of Place: Land Conservation and Clean Energy Pathways for California. *The Nature Conservancy*, 89.
5. Anders, S., & Bialek, T. (2003). *Technical Potential for Rooftop Photovoltaics in the San Diego Region*. EPIC.
6. SANDAG. (2021, March 25). *Conserved Lands*. SanGIS/SANDAG GIS Data Warehouse. https://rdw.sandag.org/Account/gisdtview?dir=Ecology
7. Ong, S., Campbell, C., Denholm, P., Margolis, R., & Heath, G. (2013). *Land-Use Requirements for Solar Power Plants in the United States* (NREL/TP-6A20-56290, 1086349; p. NREL/TP-6A20-56290, 1086349). NREL. https://doi.org/10.2172/1086349
8. Denholm, P., Hand, M., Jackson, M., & Ong, S. (2009). *Land Use Requirements of Modern Wind Power Plants in the United States* (NREL/TP-6A2-45834, 964608; p. NREL/TP-6A2-45834, 964608). NREL. https://doi.org/10.2172/964608
9. Bayeh, C. Z., & Moubayed, N. (2014). Comparison between PV farm, solar chimney and CSP tower in Lebanon: Economical study for 100 MW power plant. *International Conference on Renewable Energies for Developing Countries 2014*, 205–210. https://doi.org/10.1109/REDEC.2014.7038557
10. Bishoyi, D., & Sudhakar, K. (2017). Modeling and performance simulation of 100MW PTC based solar thermal power plant in Udaipur India. *Case Studies in Thermal Engineering*, *10*, 216–226. https://doi.org/10.1016/j.csite.2017.05.005
11. Miao, B., & Chan, S. H. (2019). The Profitability Estimation of a 100 MW Power-to-Gas Plant. *Energy Procedia*, *156*, 310–314. https://doi.org/10.1016/j.egypro.2018.11.147
12. US Census. (2019). *TIGER/Line Shapefile, 2019, 2010 nation, U.S., 2010 Census Urban Area National* [Data set]. Unknown. https://catalog.data.gov/dataset/tiger-line-shapefile-2019-2010-nation-u-s-2010-census-urban-area-national
13. EIA. (2021). *Form EIA-860 detailed data with previous form data (EIA-860A/860B)*. https://www.eia.gov/electricity/data/eia860/
14. NREL. (2020). *Index | Electricity | 2020 | ATB | NREL*. https://atb.nrel.gov/electricity/2020/index
15. Cohen, S. M., Becker, J., Bielen, D. A., Brown, M., Cole, W. J., Eurek, K. P., Frazier, A., Frew, B. A., Gagnon, P. J., Ho, J. L., Jadun, P., Mai, T. T., Mowers, M., Murphy, C., Reimers, A., Richards, J., Ryan, N., Spyrou, E., Steinberg, D. C. (ORCID:0000000317692261), … Zwerling, M. (2019). *Regional Energy Deployment System (ReEDS) Model Documentation: Version 2018* (NREL/TP-6A20-72023). National Renewable Energy Lab. (NREL), Golden, CO (United States). https://doi.org/10.2172/1505935
16. DHS. (2020, June). *Electric Substations*. https://hifld-geoplatform.opendata.arcgis.com/datasets/electric-substations/explore
17. Masters, G. M. (2004). *Renewable and Efficient Electric Power Systems: Masters/Electric Power Systems*. John Wiley & Sons, Inc. https://doi.org/10.1002/0471668826
18. Barbose, G., Darghouth, N., O'Shaugnessey, E., & Forrester, S. (2020). *Tracking the Sun | Electricity Markets and Policy Group*. Berkeley Labs. https://emp.lbl.gov/tracking-the-sun

19. RESOLVE: Renewable Energy Solutions Model. (n.d.). *E3*. Retrieved August 31, 2021, from https://www.ethree.com/tools/resolve-renewable-energy-solutions-model/
20. USDA. (2020). *CropScape—NASS CDL Program*. National Agricultural Statistics Service. https://nassgeodata.gmu.edu/CropScape/
21. SANDAG. (2021, August 26). *Eco Vegetation Layer*. SanGIS/SANDAG GIS Data Warehouse. https://rdw.sandag.org/Account/gisdtview?dir=Ecology
22. SANDAG. (2010). *Developable Land*. https://www.sandag.org/resources/maps_and_gis/gis_downloads/downloads/zip/Land/ForecastLand/devabledoc.htm#codes
23. City of San Diego. (2021). *Climate Equity and Jobs | Sustainability | City of San Diego Official Website*. https://www.sandiego.gov/sustainability/social-equity-and-job-creation
24. City of San Diego. (2018). *Climate Equity Index Report*. https://www.sandiego.gov/sites/default/files/2019_climate_equity_index_report.pdf
25. SANDAG. (2011). *Social Equity: Title VI and Environmental Justice*. https://www.sandag.org/uploads/2050RTP/F2050rtp4.pdf
26. OEHHA, O. (2014, November 27). *CalEnviroScreen*. https://oehha.ca.gov/calenviroscreen
27. CalEPA. (2021). *California Climate Investments to Benefit Disadvantaged Communities | CalEPA*. https://calepa.ca.gov/envjustice/ghginvest/
28. Revesz, Richard L., Air Pollution and Environmental Justice (September 24, 2021). *Ecology Law Quarterly*, Forthcoming, Available at SSRN: https://ssrn.com/abstract=3930215
29. Clean Coalition. San Diego Solar Siting Survey - Task 2.2 Final Summary Report: Solar Photovoltaic (PV) Commercial-Scale Sites for 1,000 kWac and Larger. (2018).
30. CPUC. (2021). *Portfolios and Modeling Assumptions for the 2021-2022 Transmission Planning Process*. https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-power-procurement/long-term-procurement-planning/2019-20-irp-events-and-materials/portfolios-and-modeling-assumptions-for-the-2021-2022-transmission-planning-process
31. Gao, J., & O'Neill, B. C. (2020). Mapping global urban land for the 21st century with data-driven simulations and Shared Socioeconomic Pathways. *Nature Communications*, *11*(1), 2302. https://doi.org/10.1038/s41467-020-15788-7
32. Shaner, M. R., Davis, S. J., Lewis, N. S., & Caldeira, K. (2018). Geophysical constraints on the reliability of solar and wind power in the United States. *Energy & Environmental Science*, *11*(4), 914–925. https://doi.org/10.1039/C7EE03029K
33. Olson, A., Allen, D., Li, V., Leslie, E. (2017). Planning Transmission for Renewables: Optimizing use of California's transmission system to deliver energy from renewable resources in the San Joaquin Valley. E3 technical report.
34. Hamoud, G., & Bradley, I. (2004). Assessment of transmission congestion cost and locational marginal pricing in a competitive electricity market. *IEEE Transactions on Power Systems*, *19*(2), 769–775. https://doi.org/10.1109/TPWRS.2004.825823
35. Gu, Y., Xie, L., Rollow, B., & Hesselbaek, B. (2011). Congestion-induced wind curtailment: Sensitivity analysis and case studies. *2011 North American Power Symposium*, 1–7. https://doi.org/10.1109/NAPS.2011.6025167
36. CAISO. (2021). *Transmission Capability Estimates for use in the CPUC's Resource Planning Process*. 15.
37. CAISO. (2021). *California ISO - 20-Year transmission outlook*. https://stakeholdercenter.caiso.com/RecurringStakeholderProcesses/20-Year-transmission-outlook
38. EIA. (2021). *Levelized Costs of New Generation Resources in the Annual Energy Outlook 2021* (p. 25).
39. Clack, C., Choukulkar, A., Coté, B., McKee, S. (2020). Why Local Solar For All Costs Less: A New Roadmap for the Lowest Cost Grid. Vibrant Clean Energy Technical Report.

40. Ireland, E. (2021, August 19). Supervisors OK Large Solar Project in Jacumba Hot Springs Over Residents' Objections. *Times of San Diego*. https://timesofsandiego.com/politics/2021/08/18/supervisors-ok-large-solar-project-in-jacumba-hot-springs-residents-object/
41. Firestone, J., & Kirk, H. (2019). A strong relative preference for wind turbines in the United States among those who live near them. *Nature Energy*, *4*(4), 311–320. https://doi.org/10.1038/s41560-019-0347-9
42. Sonnberger, M. (2019). Choosing the lesser of two evils? *Nature Energy*, *4*(4), 265–266. https://doi.org/10.1038/s41560-019-0354-x

Appendix 2.A RETI Exclusions

Table 2.A.1 Category 1 Environmental Exclusions

Category 1 Lands	
Federal Lands	State Lands
Designated Federal Wilderness Areas	Private Preserves of The Wildlands Conservancy
Wilderness Study Areas	
National Wildlife Refuges	
Units of National Park System (National Parks, National Monuments, National Recreation Areas, National Historic Sites, National Historic Parks, National Preserves)	Existing Conservation Mitigation banks under conservation easement approved by the state Department of Fish and Game, U.S. Fish and Wildlife Service or Army Corps of Engineers
Inventoried Roadless Areas on USFS national forests	CA State Defined Wetlands
National Historic and national Scenic Trails	CA State Wilderness Areas
National Wild, Scenic and Recreational Rivers	CA State Parks
BLM King Range Conservation Area, Black Rock-High Rock National Conservation Area, and Headwaters Forest Reserve	DFG Wildlife Areas and Ecological Reserves
BLM National Recreational Areas	
BLM National Monuments	
Lands precluded by development under Habitat Conservation Plans and Natural Community Conservation Plans	
Lands specified as of May 1, 2008, in Proposed Wilderness Bills (S. 493, H.R. 3682)	

Adapted from RETI, 2009

Table 2.A.2 Category 2 Environmental Exclusions

Category 2 Lands
BLM Areas of Critical Environmental Concern
USFWS designated Critical Habitat for federally listed endangered and threatened species
Special wildlife management areas identified in BLM's West Mojave Resource Management Plan. I.e., Desert Wildlife Management Areas and Mojave Ground Squirrel Conservation Areas
Lands purchased by private funds and donated to BLM, specifically the California Desert Acquisition Project by The Wildlands Conservancy
"Proposed and Potential Conservation Reserves" in HCPs and NCCPs

Adapted from RETI, 2009

Table 2.A.3 Full List of Exclusions for RETI CPA Site Selection

RETI Excluded Lands				
	Geothermal	Solar PV	Wind	Notes
Category 1 lands	Yes	Yes	Yes	
Category 2 lands	Yes	Yes	Yes	Pre-identified projects OK
Wetlands and water bodies	Yes	Yes	Yes	Dry lakes not excluded
Native American reservations	Yes	Yes	Yes	Pre-identified projects OK
Military lands	Yes	Yes	Yes	Pre-identified projects OK
Mines (surface)	Yes	Yes	Yes	
Urban areas	Yes	Yes, + buffer	Yes, + buffer	buffer up to 3 miles depending on population
Airports	Yes	Yes	Yes, + buffer	Major airports only. Wind buffer is up to 5 miles
Military flyways	No	No	Yes	Pre-identified projects OK in red zones. All other open
Williamson Act Prime Agricultural Land	No	Yes	No	Pre-identified projects OK in red zones. All other open
Williamson Act Non-Prime Agricultural Land	No	Yes	No	Excluded until 2018, pre-identified projects OK
Renewable resource quality	No	No	< 6.3 m/sec	
Min. contiguous square acreage	No	160	none	640 acres = 1 section = 1 sq mile
Land slope	No	> 5%	> 20%	Geothermal evaluated on case by case basis

Adapted from RETI, 2009

Appendix 2.B Downscaling Method

First, the proportion of the population of San Diego with respect to the population of Southern California (SC) is found. The SC population is defined as all counties south of the PG&E territory[viii]. Therefore, using the following formula to find a result of 13.75%.

$$Population\ of\ San\ Diego\ County\ /\ Population\ of\ SC\ Counties$$

Table 2.B.1 Proportion of Population in San Diego

San Diego Percentage of Southern CA	
San Diego	3,315,404
Total	24,106,838
SD %	**13.75%**

Then the modeled final energy demand ("d-energy" in the Overall Energy System Model) is used. First, the total energy demand is filtered to "electricity" and "Southern California". Then the sum of electricity demand is found for all years 2018 - 2050. The proportion of Southern California population in San Diego (13.75%) is applied to find the San Diego electricity demand. Finally, 4,115 GWh of existing and planned solar and wind resources within the County is removed. The total resource requirements based on demand are found in Table 2.B.2.

Table 2.B.2 Necessary Renewable Resources to Meet 100% of Demand

Year	**Total GWh**
2020	19,158
2025	20,919
2030	26,689
2035	34,825
2040	42,412
2045	47,045
2050	**49,979**

viii PG&E, 2014. https://www.pge.com/tariffs/assets/pdf/tariffbook/GAS_MAPS_Service_Area_Map.pdf

Appendix 2.C Vegetation Types in San Diego with High CO_2 Sequestration Potential

Non-Native Vegetation
Disturbed Wetland
Disturbed Habitat
General Agriculture
Orchards and Vineyards
Southern Coastal Bluff Scrub
Coastal Scrub
Maritime Succulent Scrub
Diegan Coastal Sage Scrub
Diegan Coastal Sage Scrub: Coastal form
Diegan Coastal Sage Scrub: Inland form
Riversidian Sage Scrub
Riversidian Upland Sage Scrub
Alluvial Fan Scrub
Sonoran Desert Scrub
Sonoran Creosote Bush Scrub
Sonoran Desert Mixed Scrub
Sonoran Mixed Woody Scrub
Sonoran Mixed Woody and Succulent Scrub
Sonoran Wash Scrub
Colorado Desert Wash Scrub
Encelia Scrub
Acacia Scrub
Mojavean Desert Scrub
Blackbush Scrub
Great Basin Scrub
Sagebrush Scrub
Big Sagebrush Scrub
Desert Saltbush Scrub
Desert Sink Scrub
Chaparral
Southern Mixed Chaparral
Granitic Southern Mixed Chaparral
Mafic Southern Mixed Chaparral
Northern Mixed Chaparral
Granitic Northern Mixed Chaparral
Mafic Northern Mixed Chaparral
Chamise Chaparral
Granitic Chamise Chaparral
Mafic Chamise Chaparral
Red Shank Chaparral
Semi-Desert Chaparral
Montane Chaparral
Mixed Montane Chaparral
Montane Manzanita Chaparral
Montane Ceanothus Chaparral
Montane Scrub Oak Chaparral
Upper Sonoran Ceanothus Chaparral
Ceanothus crassifolius Chaparral
Scrub Oak Chaparral
Upper Sonoran Subshrub Scrub
Valley and Foothill Grassland
Native Grassland
Valley Needlegrass Grassland
Valley Sacaton Grassland
Non-Native Grassland: Broadleaf-Dominated
Foothill/Mountain Perennial Grassland
Transmontane Perennial Grassland
Vernal Pool
San Diego Mesa Vernal Pool
San Diego Mesa Claypan Vernal Pool
Meadows and Seeps
Montane Meadow
Wet Montane Meadow
Dry Montane Meadows
Alkali Meadows and Seeps
Alkali Playa Community
Southern Coastal Salt Marsh
Alkali Marsh
Cismontane Alkali Marsh
Freshwater Marsh
Coastal and Valley Freshwater Marsh
Transmontane Freshwater Marsh
Emergent Wetland
Riparian and Bottomland Habitat
Riparian Forests
Southern Riparian Forest
Southern Coast Live Oak Riparian Forest
Southern Arroyo Willow Riparian Forest
Southern Cottonwood-Willow Riparian Forest
White Alder Riparian Forest
Sonoran Cottonwood-Willow Riparian Forest
Mesquite Bosque
Riparian Woodlands
Desert Dry Wash Woodland
Desert Fan Palm Oasis Woodland
Southern Sycamore-Alder Riparian Woodland
Southern Riparian Woodland
Riparian Scrubs
Southern Riparian Scrub
Mule Fat Scrub
Southern Willow Scrub
Arundo donnax Dominant/Southern Willow Scrub
Great Valley Scrub
Great Valley Willow Scrub
Colorado Riparian Scrub
Arrowweed Scrub
Intertidal
Shallow Bay
Estuarine
Saltpan/Mudflats
Woodland
Cismontane Woodland
Oak Woodland
Black Oak Woodland
Coast Live Oak Woodland
Open Coast Live Oak Woodland
Dense Coast Live Oak Woodland
Engelmann Oak Woodland
Open Engelmann Oak Woodland
Dense Engelmann Oak Woodland
Peninsular Pinon and Juniper Woodlands
Peninsular Pinon Woodland
Peninsular Juniper Woodland and Scrub
Elephant Tree Woodland
Mixed Oak Woodland
Undifferentiated Open Woodland
Non-Native Woodland
Eucalyptus Woodland
Mixed Evergreen Forest
Oak Forest
Coast Live Oak Forest
Canyon Live Oak Forest
Black Oak Forest
Torrey Pine Forest
Southern Interior Cypress Forest
Lower Montane Coniferous Forest
Coast Range, Klamath and Peninsular Coniferous Forest
Coulter Pine Forest

Bigcone Spruce (Bigcone Douglas Fir)-Canyon Oak Forest
Sierran Mixed Coniferous Forest
Mixed Oak/Coniferous/Bigcone/Coulter Forest
Jeffrey Pine Forest
Interior Live Oak Chaparral
Southern Maritime Chaparral
Coastal Sage-Chaparral Transition
Montane Buckwheat Scrub

Appendix 2.D List of Key Assumptions

Key Assumptions

- Solar is prioritized over wind within San Diego County.
- Cost of transmission can be approximated by cost of Euclidian distance from CPA to nearest substation.
- Total geothermal resource potential identified by E3 and CPUC as part of the statewide Integrated Resource Plan (R-20-05-003) will be operation by 2030.
- Geothermal supply in Imperial is shared with San Diego in an amount equivalent to the ratio of their combined population.
- Electricity demand model results can be downscaled by the ratio of San Diego population to total Southern California population.
- Storage will meet intermittency demands.
- No offshore wind.
- Cost is the most important criteria for site selection.
- The Overall Energy Model Central Case is the best forecast for the purposes of the spatial analysis.
- The capacity factor is equal to the fixed-tilt solar percentage in the urban areas and tracking solar in non-urban areas.
- Infill solar sites are grid connected.
- All planned and permitted solar sites in San Diego County will be constructed.
- SANDAG's Conserved Land areas are undesirable for renewable development.

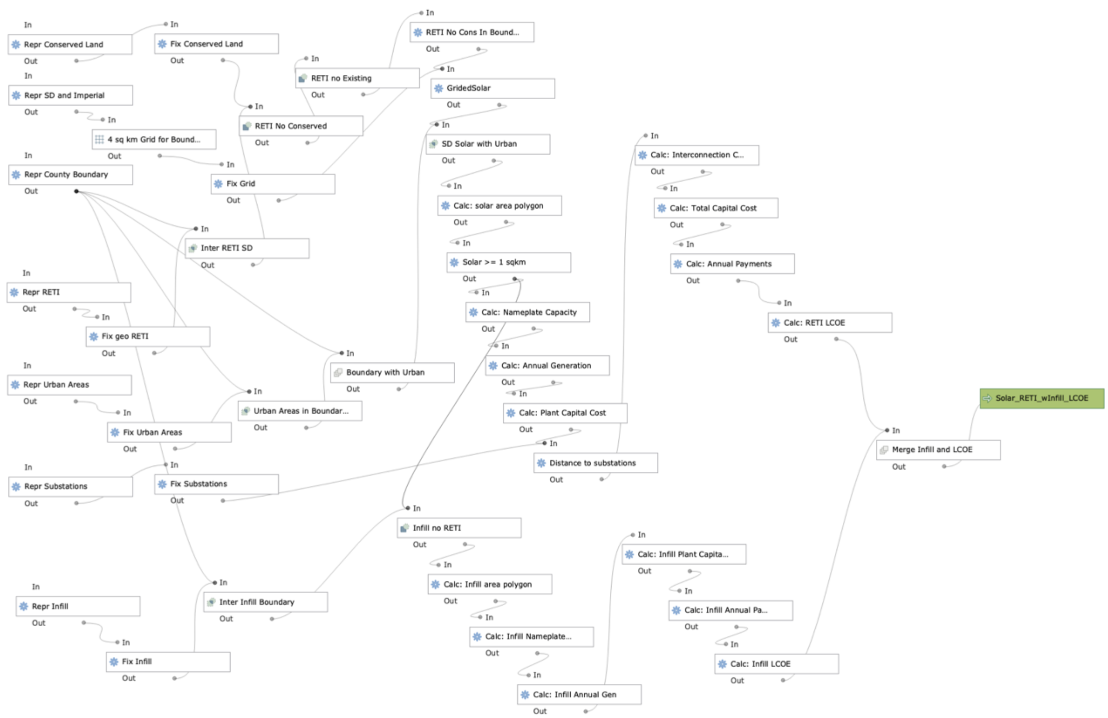
Appendix 2.E List of Spatial Data Sources

Spatial Sources

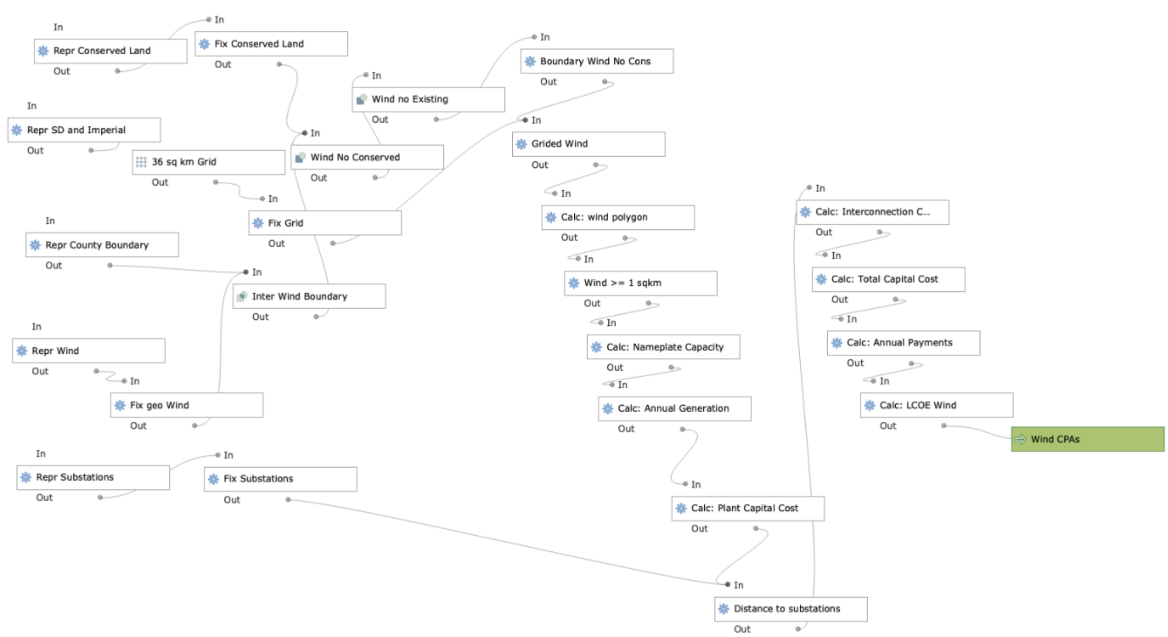
1. **Utility-Scale Wind and Solar Polygons:** California Renewable Energy Transmission Initiative, 2009. https://grist.org/wp-content/uploads/2009/11/reti-1000-2009-001-f.pdf
2. **Infill Solar Polygons:** The Nature Conservancy, Power of Place, 2019 (update to 2019 report, not published). https://www.nature.org/en-us/about-us/where-we-work/united-states/california/stories-in-california/clean-energy/
3. **Conserved Lands Exclusions:** San Diego Association of Governments, 2021. https://rdw.sandag.org/Account/gisdtview?dir=Ecology
4. **Existing Utility-Scale Solar and Wind Polygons**: Polygons created based on existing and planned sites identified by EIA, 2021 https://www.eia.gov/electricity/data/eia860/
5. **Existing Substations:** Department of Homeland Security, Homeland Infrastructure Foundation-Level Data, 2021. https://hifld-geoplatform.opendata.arcgis.com/datasets/electric-substations
6. **Urban Areas**: US Census, 2019. https://catalog.data.gov/dataset/tiger-line-shapefile-2019-2010-nation-u-s-2010-census-urban-area-national
7. **Transmission Networks:** Department of Homeland Security, Homeland Infrastructure Foundation-Level Data, 2021. https://hifld-geoplatform.opendata.arcgis.com/datasets/electric-power-transmission-lines/explore?location=25.606388%2C-7.477918%2C2.79
8. **Geothermal Sites:** Points created based on data from E3 and CPUC as part of the statewide Integrated Resource Plan (R-20-05-003) https://www.ethree.com/tools/resolve-renewable-energysolutions-model/
9. **Low Environmental Impact CPAs**: Wu et al., 2020 Data Github https://github.com/grace-cc-wu/LandUsePathwaysTo100
10. **Land Value:** USDA Cropland Data Layer https://www.nass.usda.gov/Research_and_Science/Cropland/SARS1a.php
11. **High Sequestration Potential**: Taken from analysis in the Land Use chapter, the SANDAG “Eco Veg” dataset is used. https://www.sangis.org/
12. **Developable Land:** Vacant or Agricultural Redevelopment Land Use. SANDAG, Developable Land, 2010. https://www.sandag.org/resources/maps_and_gis/gis_downloads/land.asp

Appendix 2.F QGIS Processing Modeler

Solar CPAs Modeler



Wind CPAs Modeler



3. Accelerating Deep Decarbonization in the Transportation Sector

Chelsea Richer, Fehr & Peers
Katy Cole, Fehr & Peers
Eleanor Hunts, Fehr & Peers

Key Takeaways

- Based on the regional policy context including SANDAG's Draft 2021 Regional Plan, the County's Electric Vehicle Roadmap, local jurisdiction policies and guiding documents, and the A2Z Gap Analysis, the County has a strong policy foundation for reducing emissions related to transportation.
- Nevertheless, projected annual emissions in 2045 and 2050 are inconsistent with the levels of reductions required by EO S-3-05, EO B-30-15, and EO-B-55-18 for carbon neutrality.
- This chapter shows where opportunity areas exist to accelerate EV adoption and VMT reduction based on existing countywide policies and patterns of vehicle ownership, travel behavior, and land use development.

3.1 Introduction

Over the last two decades, California has led the country in pioneering a number of policy solutions to mitigate climate change-related hazards and create a sustainable economy. In 2006 the state legislature passed AB 32, which established a program to combat climate change and set a goal to reduce statewide greenhouse gas (GHG) emissions to 1990 levels by 2020. Recognizing that the transportation sector is the largest source of GHG emissions statewide, California has adopted several additional transportation-focused measures since that initial landmark climate bill. One such law is the Sustainable Communities and Climate Protection Act of 2008 (SB 375). SB 375 targets cars and light-duty trucks and directs the California Air Resources Board (CARB) to set regional GHG reduction targets for each metropolitan planning organization (MPO). It requires MPOs to incorporate a set of GHG reduction strategies, called a Sustainable Communities Strategy, into their Regional Transportation Plans.

A series of executive orders signed over the years have further contributed to the state's climate platform. EO S-3-05 set a goal to reduce GHG emissions to 80 percent below 1990 levels by 2050, B-30-15 set an interim goal of reducing emissions to 40 percent below 1990 levels by 2030, and B-55-18 called for the state to achieve carbon neutrality by 2045 at the latest.

Electrification of end-use services and decarbonization of electricity generation have been identified as key pathways to achieving a low-carbon future (Appendix A). Additional Executive Orders and state legislation have established targets for Zero Emission Vehicles (ZEVs) and related charging infrastructure. EO B-48-18 established goals for 200 hydrogen fueling stations and 250,000 EV charging stations (including 10,000 DC fast chargers) to support 1.5 million ZEVs on the road in California by 2025 and 5 million ZEVs on the road by 2030. AB 2127, signed in 2018, requires the CARB and the Public Utilities Commission (PUC) to prepare a statewide assessment of EV charging infrastructure needed to support levels of EV adoption required to meet the goals of EO-B-48-18. Finally, EO N-79-20 laid out a set of transportation decarbonization targets, including a mandate that 100 percent of in-state sales of new passenger cars and trucks are zero emission by 2035 and that operations of medium- and heavy-duty vehicles are zero emission by 2045.

The remainder of this chapter describes the regional policy context for the transportation sector, the modeling efforts that underpin land use and transportation plans in the region, and policy pathways to decarbonization through accelerated adoption of EVs, accelerated reduction of vehicle miles traveled (VMT), and continued investment in vehicle and fuel technology.

3.2 Regional Policy Context

The San Diego region has undertaken a number of transportation decarbonization efforts to date, which include a variety of VMT reduction strategies and electrification strategies. This section details the relevant policy documents that will continue to shape San Diego County's ability to reach accelerated decarbonization targets.

SANDAG's Draft 2021 Regional Plan & 5 Big Moves

The San Diego Association of Governments (SANDAG) is currently in the process of adopting the Draft 2021 Regional Plan, a blueprint for land use and transportation planning in the San Diego region through 2050. This plan provides the big-picture vision for the future as well as an implementation program to make the region's transportation system "faster, fairer, and cleaner." The 2021 Regional Plan identifies a 2030 target of 450,000 EVs on the road in San Diego County, supported by 40,000 chargers.[1]

The Draft 2021 Regional Plan articulates their future investments around the 5 Big Moves, an aspirational vision that provides a framework for the 2021 Regional Plan. The 5 Big Moves include VMT reduction strategies and strategies that encourage electrification of surface transportation vehicles.[2] Over the next 30 years leading up to 2050, SANDAG will refine the transportation network and discuss a set of policies and programs to support the infrastructure and technology improvements. The five strategies in the plan are Complete Corridors, Transit Leap, Mobility Hubs, Flexible Fleets, and Next Operating System.

1. **Complete Corridors** would provide a balanced and inclusive road and highway network to maximize capacity, reduce congestion, and enable a variety of travel choices. Key features include managed lanes, Active Transportation and Demand Management (ATDM), smart high-speed communication networks, priority for shared transportation modes, and curb management. Complete Corridors are the backbone for the Flexible Fleets and Transit Leap strategies.
2. **Transit Leap** would complement Complete Corridors by creating a complete network of high-speed, high-quality transit services that connect residential areas with employment centers and attractions. Future transit services would build upon existing ones through expanded service times, higher frequency and capacity, transit priority, and better integration with other services.
3. **Mobility Hubs** are envisioned as a network of connected places with land use supportive of integrated mobility services and amenities. SANDAG's proposed network is comprised of the San Diego urban core, plus 30 surrounding hubs. Mobility Hub prototypes have been developed for eight stops along the Mid-Coast Trolley route and eight additional locations across the region.
4. **Flexible Fleets** describes the strategy of shared, on-demand transportation services which include micromobility, rideshare, microtransit, ride hailing, and last-mile delivery. This strategy relies on public-private partnership and assumes many of the new modes introduced would be electric-powered.
5. **Next Operating System (OS)** is a digital platform that compiles information from various parts of the transportation system into a centralized data hub, linking residents, businesses, and operators to real-time transportation data, and providing planners and policymakers with a new repository for analysis.

The first four of the 5 Big Moves are comprised of both strategies to reduce VMT and strategies to accelerate EV adoption, and the fifth, Next OS, is an underpinning strategy to improve data about the transportation sector so that it can continue to be analyzed and optimized over time.

Accelerate to Zero's Electric Vehicle Gap Analysis (2021)

The Accelerate to Zero (A2Z) Emissions Collaborative is an initiative by regional organizations invested in advancing transportation electrification, including the City and County of San Diego, the San Diego Air Pollution Control District, SANDAG, and San Diego Gas & Electric (SDG&E). In July 2021, it published the San Diego Regional Electric Vehicle Gap Analysis which identified existing efforts and conditions, and evaluated zero-emission infrastructure gaps and barriers. As the A2Z Collaborative continues their work, the EV Gap Analysis will facilitate prioritizing "Communities of Concern" for transportation decarbonization investments. The Gap Analysis identifies a 2030 target of 771,000 EVs on the road in San Diego County, supported by 139,000 Level 2 chargers, 16,200 DC fast chargers, and 47 hydrogen fueling stations.[3]

San Diego County's Electric Vehicle Roadmap (2019)

The County of San Diego adopted an Electric Vehicle Roadmap in October 2019, which contains six goals and 11 recommendations that leverage the County's land use authority, permitting processes, and outreach platforms in order to increase EV ownership and charging installations in the unincorporated area and at County facilities.[4] These are summarized in Table 3.1, below. Because this document relates primarily to the unincorporated area of San Diego, the numbers reported for 2030 EV targets and charger targets are substantially different than the more current SANDAG or A2Z numbers. The EV Roadmap supports the 2018 Climate Action Plan adopted by the County of San Diego.

Table 3.1. Summary of Actions in San Diego County's 2019 Electric Vehicle Roadmap

Goal	Targeted Outcome	Recommendations
County Operations Recommendations		
1. Further reduce the County's fleet of gas-powered vehicles.	Increase the number of EVs in the County's fleet to 501 by 2027.	Amend three Board policies to assist fleet EV conversion by requiring new light-duty vehicles to be EV.
		Convert 250 County fleet gas-powered vehicles to EVs by 2025 and install necessary infrastructure.
		Convert an additional 251 County fleet gas-powered vehicles to EVs for a total of 501 by 2027 and install necessary infrastructure.
		Keep pace with technological trends, track the costs and benefits of fleet conversion, and update the Green Fleet Action Plan no later than 2025 to set goals for medium- and heavy-duty fleet vehicle conversions.
2. Accelerate the installation of EV charging stations at public locations in County facilities and in the unincorporated County.	Contribute to the regional EV charging network by installing 2,040 Level II charging stations at County facilities and throughout the unincorporated area by 2028.	Amend Board policy G-15, "Design Standards for County Facilities" by 2019 to require charging infrastructure development at new County facilities.
		Install an additional 63 publicly accessible EV charging stations for a total of 100 chargers at County facilities by 2021.

		Prepare an EV charger site assessment for County facilities and the unincorporated area and install 2,040 Level II chargers.
3. Promote and incentivize County employee EV ownership.	Increase County employee EV ownership and use to reduce employee commute emissions.	Promote and incentivize County employee EV use by developing partnerships with banks, credit unions, and dealerships to extend lending and pricing benefits.
Unincorporated Area Recommendations		
4. Incentivize and/or require EV charging infrastructure in new and existing private multi-family residential and/or non-residential development.	Increase charging station installations in new and existing private development.	Prepare a cost/benefit analysis of options to incentivize and/or require EV charger installations in private development.
5. Fund EV expert/consumer advocate as a regional resource.	Increase EV ownership and charging station installations through education, outreach, regional collaboration, and incentives.	Identify regional partners and cost sharing opportunities to fund a regional EV expert/consumer advocate on an ongoing basis.
6. Collaborate with regional partners to support public and private fleet electrification.	Increase EV use in regional light-, medium-, and heavy-duty fleets.	Develop public and private regional partnerships to provide fleet electrification technical support on an ongoing basis.

San Diego County's Climate Action Plan (2018)

Through Climate Action Plans (CAPs), both the County of San Diego and many cities within the County have set out a series of measures to reduce GHG emissions over the coming decades. The County's 2018 CAP, which is currently being revised to achieve compliance with the California Environmental Quality Act (CEQA), included 11 strategies and 26 measures which focus on activities that occur within the unincorporated area of the region and within County-owned facilities.[5] The framework for the 2018 CAP is the GHG emissions inventory (baseline year 2014) and the state's GHG reduction targets. San Diego County set emissions targets of 3,147,275 and 1,926,903 $MTCO_2e$ for future years 2020 and 2030, respectively. Measures in the Built Environment and Transportation GHG emissions sector specifically are projected to help the County achieve reductions of 233,758 $MTCO_2e$ in 2030.[5]

City of San Diego's Climate Action Plan (2015)

The City of San Diego adopted its landmark CAP in 2015 and projected that its implementation would help the city surpass the target of 51 percent below 2010 GHG emissions by 2035 and maintain its trajectory to meet its proportional share of the 2050 state target. Among the local strategies for achieving the GHG reduction targets are a range of activities that aim to decrease transportation-related emissions by improving mobility and reducing VMTs. Specific implementation measures involve changing land uses, promoting alternative modes of travel, and enhancing vehicle fuel efficiency. As the largest jurisdiction in the County, the policies and actions of the City of San Diego often can help provide resources and examples against which other jurisdictions can model their approach.

Summary of Additional State, Regional, and Local Goals and Actions

In addition to the County and City of San Diego's CAPs, the other jurisdictions in the County have also adopted CAPs, with associated goals around VMT reduction, EV adoption, and emissions reductions for the transportation sector. Some have additionally developed targets and taken actions related to the adoption of EVs and/or the implementation of charging infrastructure. This regional context was included in the A2Z Gap Analysis and is summarized in Table 3.2 below.

Table 3.2. County of San Diego Jurisdictions' Relevant Goals & Actions

Jurisdiction	Relevant Goals, Targets, and Actions
Regional and State Agencies	
Caltrans District 11	● Partnering with SDG&E to provide charging at park and ride facilities throughout the region. ● Installing corridor charging at rest areas and remote inter-city travel locations.
County of San Diego	● Established streamlined permitting processes in 2017, compliant with AB 1236, to encourage EV charging infrastructure in new developments. ● Adopted the Electric Vehicle Roadmap in 2019.
North County Transit District	● Developed a Zero Emissions Bus Rollout Plan, detailing full transition by 2042. ● Planning to purchase six battery electric and eight hydrogen fueled buses by 2023.
SANDAG	● Launched Plug-In San Diego in 2015. ● Committed over $30m over 30 years to support build-out of Level 2 charger network through the San Diego County Incentive Project. ● Identified additional electrification and mode-shift opportunities through the Draft 2021 Regional Transportation Plan and associated Big 5 Moves.
San Diego Metropolitan Transit System	● Developed a transition plan to convert fleet of 800 buses to zero emissions by 2040. ● Acquired eight battery electric buses by 2021.
Cities	
Carlsbad	● Adopted residential and non-residential ordinances for EV parking. ● Adopted 2011 CAP goal to increase ZEV miles from 4.5% to 25% by 2035.
Chula Vista	● Currently, has 31% of alternatively-fueled fleet vehicles; continuing to work towards their CAP goal of 40% by 2020.

	• Installed around 120 chargers for their fleet vehicles.
Coronado	• Identified “greening” the city’s 100 fleet vehicles as a way to reduce transportation emissions.
Del Mar	• Adopted CAP goal to increase alternatively-fueled VMT to 20% in 2020 and 30% in 2035. • Adopted CAP goal to set aside 10% of on-street parking and in city lots for high-efficiency and clean vehicles by 2020.
El Cajon	• Plans to install 128 new EV charging stations at commercial developments and 79 new EV charging stations at multi-family developments by 2030.
Encinitas	• Requires new residential units to install EV charging infrastructure. • Multi-family developments must include EV charging infrastructure at 5% of the total number of parking spaces.
Escondido	• Plans to install 281 EV charging stations in park and ride lots by 2035.
Imperial Beach	• Encourages developers to install EV charging infrastructure for new and retrofit developments. • Planning to assess municipal fleet replacement timeline for switching to ZEVs.
La Mesa	• Partnered with SANDAG, San Diego Air Pollution Control District (SDAPCD), and local developers to develop strategies to increase EV infrastructure at existing multi-family complexes.
Lemon Grove	• Plans to adopt a zoning ordinance requiring installation of EV charging infrastructure at 5% of the total number of parking spaces at new multi-family and commercial developments.
National City	• Installed charging stations at City Hall. • Partnered with SDG&E to install EV charging infrastructure across the City.
Oceanside	• Plans to require new single-family developments to include prewiring to enable 240-volt charging.
Poway	• Installed 11 EV charging stations around the City.
San Diego	• Adopted CAP goal to convert 90% of gas-powered municipal fleet vehicles to zero emission by 2035. • Installed 57 public EV charging stations at City facilities.
San Marcos	• Will require (starting in 2021) new multi-family and commercial developments to include EV charging infrastructure at 5% of total number of parking spaces.
Santee	• Requires all new residential and commercial developments to install e-chargers.
Solana Beach	• Collaborating with SANDAG to increase EVs in the City.
Vista	• Requires new multi-family developments to have 3% of total parking spaces equipped with EV charging infrastructure.

	• Requires new commercial developments to have 6% of total parking spaces equipped with EV charging infrastructure.
Source: San Diego Regional EV Gap Analysis, July 2021; SANDAG Draft 2021 Regional Plan.	

3.3 Transportation Modeling & Emissions Forecasts

In support of this Regional Decarbonization Framework, Fehr & Peers has undertaken a review of the assumptions and outcomes of the San Diego Association of Governments (SANDAG) regional model and Evolved Energy's EnergyPATHWAYS model described in Appendix A. There are fundamental differences between the two models. **SANDAG** uses an activity-based model (ABM) that simulates individual and household transportation decisions at a detailed level. The most current model is ABM2+, which is being used to support the 2021 Regional Plan. **EnergyPATHWAYS** estimates energy use and GHG emissions given a specific electrification trajectory and fleet composition.

SANDAG's ABM2+ simulates travel behavior in the San Diego region using land use and transportation network data to estimate VMTs and estimate corresponding GHG emissions. ABM2+ starts with a street-based active transportation network, a highway network, and a transit network. The resident transportation model, disaggregate models, and aggregate models are executed, and the resulting trip tables are summed up and used by an iterative traffic assignment process. The outputs – specifically, VMT by speed bin and vehicle classification – are then converted off-model to greenhouse gas emissions using Emission Factors (EMFAC) emissions factors.

EnergyPATHWAYS is a stock accounting tool from Evolved Energy that quantifies all energy infrastructure. The transportation portion of the model uses service demand projections, existing vehicle stock, and efficiency measures to estimate total emissions. The model can be made applicable to varying geographies across the nation by modifying the underlying parameters. In the context of California, it uses the 100% zero-emission vehicle (ZEV) sales by 2035 goal and makes assumptions about adoption of EV technologies. In this model, decarbonization comes from fuel shifts, not mode shifts. As such, many factors that are central to ABM2+, such as vehicle miles traveled (VMT), are not considered.
For the purposes of this chapter, the 2021 Regional Transportation Plan and SANDAG's ABM2+ are discussed further. At the conclusion of this chapter, Table 3.7 provides a summarized comparison between the two models, and Appendix A of the Regional Decarbonization Framework provides full technical documentation for the EnergyPATHWAYS model.

SANDAG Emissions Forecasts

As described above, SANDAG's Draft 2021 Regional Plan includes policy and transportation investment initiatives that are referred to as the 5 Big Moves, which include Complete Corridors, Transit Leap, Mobility Hubs, Flexible Fleets, and Next Operating System. Together, these five key strategies for mobility aim to deliver an efficient and equitable transportation system that meets state climate targets and local Climate Action Plan goals. However, these policies and actions are not sufficient to meet the requirements of EO S-3-05 and EO B-55-18, as described in the emissions forecasts included in the Draft 2021 Regional Plan EIR. In order to reach deep decarbonization goals, additional efforts will be necessary both to rapidly electrify the surface transportation sector and to reduce VMT.

The Draft EIR for the Draft 2021 Regional Plan evaluates environmental impacts related to regional growth and land use change as well as the transportation network improvements and programs of the 5 Big Moves together because the per-capita CO_2 emissions from vehicles addressed by state targets are influenced by the combined effects of both components. ABM2+ models the effect of the 5 Big Moves in conjunction with the rest of the 2021 Regional Plan through four forecast scenarios: Baseline Year 2016, interim years 2025 and 2035, and Horizon Year 2050.

Compared to existing conditions, the Draft EIR reports that the regional growth, land use change, and transportation network improvements included in the 2021 Regional Plan would result in a reduction of GHG emissions across all sectors for all interim and horizon years. These reductions are summarized in Figure 3.1, which shows GHG impact of Passenger Cars and Light-Duty Vehicles with and without the SAFE Rule Impact (the SAFE Rule sets national fuel economy standards instead of California standards). For Passenger Cars and Light-Duty Vehicles, emissions are also forecasted to decrease for all interim and horizon years. For Heavy-Duty Trucks and Vehicles, emissions are forecasted to remain the same from 2025 onward. For Rail, emissions are forecasted to increase between 2016 and 2050. Projected annual emissions in 2045 and 2050 (18 $MMTCO_2e$ across all sectors and 7.6 $MMTCO_2e$ for the Surface Transportation sector, including Passenger & Light-Duty with no SAFE Rule impact, Heavy-Duty & Trucks, and Rail) would be inconsistent with the levels of reductions required by EO S-3-05, EO B-30-15, and EO-B-55-18.[ix]

Per SB 375, specific GHG emissions reduction targets for the transportation sector are not yet established for Horizon Year 2050, but the target established for SANDAG for 2035 is to reduce

[ix] EO S-3-05 requires a reduction of GHG emissions to 80 percent below 1990 levels by 2050. EO B-30-15 requires a reduction of GHG emissions to 40 percent below 1990 levels by 2030. EO B-55-18 requires carbon neutrality across all sectors by 2045.

per capita CO_2 emissions from passenger cars and light-duty vehicles to 19 percent below 2005 levels. As shown in Figure 3.2, implementation of the 2021 Regional Plan would reduce per capita CO_2 emissions from this sub-sector of Surface Transportation to 20 percent below 2005 levels by 2035, and therefore would meet SB 375 targets.

Summary of 2016 Greenhouse Gas Inventory and Greenhouse Gas Projections

Greenhouse Gas Emissions (MMT CO_2e)						
Emissions Category	**2016**	**2025**	**2030**	**2035**	**2045**	**2050**
Passenger Cars and Light-Duty Vehicles* (No SAFE Rule Impact)	10.5	8.0 (7.8)	7.4 (6.9)	6.5 (5.9)	6.4 (5.7)	6.4 (5.7)
Electricity	5.3	3.4	1.9	1.3	0.2	0.2
Natural Gas	3.1	3.3	3.4	3.4	3.5	3.6
Industrial	2.1	2.2	2.3	2.4	2.5	2.5
Heavy-Duty Trucks and Vehicles	1.8	1.7	1.7	1.7	1.7	1.7
Other Fuels	1.1	1.4	1.4	1.5	1.5	1.5
Off-Road Transportation	0.62	0.72	0.79	0.83	0.91	0.95
Solid Waste	0.59	0.62	0.64	0.65	0.67	0.67
Water	0.24	0.28	0.22	0.15	-	-
Aviation	0.21	0.29	0.32	0.34	0.40	0.43
Rail	0.11	0.17	0.18	0.19	0.20	0.20
Wastewater	0.07	0.08	0.08	0.08	0.08	0.08
Agriculture	0.05	0.06	0.06	0.06	0.06	0.06
Marine Vessels	0.05	0.06	0.06	0.06	0.08	0.08
Soil Management	0.05	0.04	0.04	0.04	0.04	0.04
Total* (Total: No SAFE Rule Impact)	**26**	**22 (22)**	**20 (20)**	**19 (18)**	**18 (18)**	**18 (18)**

MMT – million metric tons, SAFE Rule – Federal Safer Affordable Fuel-Efficiency Vehicles Rule, April 2020
*Includes GHG impact of SAFE Rule
2016 is an inventory year, the rest are forecast years. The GHG emissions projections include the impact of federal and State regulations and regional policies and programs to reduce GHG emissions.

Source: Energy Policy Initiatives Center, University of San Diego 2021

Figure 3.1. Summary of 2016 Greenhouse Gas Inventory and Greenhouse Gas Projections. Source: SANDAG.

	Per Capita Reductions from 2005 Levels
Per Capita Reduction under the Proposed Plan (On-Model Results Only)	-19.03%
Per Capita Reduction under the Proposed Plan (Off-Model Results Only)	-3.05%
CARB Adjustment Factor for EMFAC 2007–2014[1]	+1.7%
Induced Demand Adjustment Factor[2]	+0.38%
Per Capita Reductions	-20.0%

San Diego Forward: The 2021 Regional Plan
Program Environmental Impact Report
Page 4.8-27

4.8 Greenhouse Gas Emissions

	Per Capita Reductions from 2005 Levels
CARB Target	-19%

Source: Appendix I.
[1] The GHG reductions for the 2021 Regional Plan were calculated using the CARB model EMFAC 2014 and adjustment factors provided by CARB to account for differences in emissions rates between EMFAC 2007 (used to set the original targets in 2010) and EMFAC 2014.
[2] The induced demand adjustment factor methodology is described in Attachment 3 of Appendix I.

Figure 3.2. SB 375 GHG Reduction Targets under the Proposed Plan from Passenger Vehicles and Light-Duty Trucks, 2035, (2021 Regional Plan EIR Table 4.8-9).

3.4 Decarbonization Strategies: Policy Pathways to Close the Gap

Based on the regional policy context summarized above, including SANDAG's Draft 2021 Regional Plan, the County's Electric Vehicle Roadmap, local jurisdiction policies and guiding documents, and the A2Z Gap Analysis, the County has a strong policy foundation for reducing emissions related to transportation. The remainder of this section describes the ways in which the County can accelerate actions needed to achieve regional decarbonization of the transportation sector through accelerated EV adoption, accelerated VMT reduction, and vehicle and fuel technology improvements.

Accelerate EV Adoption

Within the 5 Big Moves and the 2021 Regional Plan more broadly, electrification is identified as a major factor in reaching regional GHG emissions reduction targets in the following ways:

- Establishes incentives to incorporate EVs into Flexible Fleets and Transit Leap
- Includes programs that could increase the number of EVs and charging stations throughout the region and within Mobility Hubs as part of the Complete Corridor strategy
- Centers Mobility Hubs around EV charging infrastructure
- Incorporates transitioning into a zero-emission fleet for the Flexible Fleet strategy

While Complete Corridors' main goal is to promote a switch from single occupancy driving to modes such as transit, shared rides, and active transportation, the initiative would help the San Diego region reach its 2030 electrification goals. The plan does not lay out a timeline for how the Transit Leap strategy will aid electrification, but it does promote the idea that new and existing services can switch to alternative fuel sources and electric power. Per the plan documentation, it is likely that future high-speed rail projects will be powered by a combination of both diesel and electricity. **In order to accelerate electrification through this strategy, SANDAG would need to adopt an aggressive implementation timeline for Complete Corridors and Transit Leap, focusing on implementation in the parts of the County where transit will be most viable and well-utilized.**

The 5 Big Moves documentation also mentions several partnerships and policies that can assist with public charging and hydrogen fueling stations build-out. These include the CALeVIP San Diego County Incentive Project, which in late 2020 began providing rebates for placement of public level 2 and direct current fast charging stations, and coordination with SDG&E to manage the demands that EV charging places on the grid. SANDAG and SDG&E are also working to provide programs that install charging stations for workplaces, multi-unit dwelling communities, and medium- and heavy-duty vehicles. **In order to accelerate electrification through this strategy, SANDAG and SDG&E would need to increase the levels of incentives and rapidly advance EV charging infrastructure installations, focusing first on Communities of Concern (CoCs) and then in places where transit is not yet viable.**

In addition to the 5 Big Moves components related to electrification, San Diego regional actions and policies to accelerate EV adoption are articulated in the A2Z EV Gap Analysis. Although the main goal of the Gap Analysis was to identify needs in order to inform a long-term strategy, the report captured some initial solutions that can inform the strategy. These include:

- Lowering the upfront costs of EV ownership through incentives, targeting the new and secondary market
- Leveraging cooperative buying for medium- and heavy-duty fleets

- Exploring alternatives to vehicle-purchase incentives, including low-emission zones, EV mandates, ordinances, or registration controls to enforce emissions standards
- Streamlined permitting for charging infrastructure
- Prioritization of infrastructure in communities of concern
- Coordinated education campaigns for end users, property owners, and frontline salespeople
- Workforce training for commercial drivers and automotive maintenance workers

Downscaled Geographic EV Adoption Targets

The A2Z Gap Analysis identifies an EV population target of 771,000 across San Diego by 2030. This target is substantially higher than SANDAG's reported target in the Draft 2021 Regional Plan, but provides an upper-limit estimate of San Diego's regional share of the state-wide target. For the purposes of downscaling to local jurisdictions in San Diego County, Fehr & Peers has used the A2Z target numbers rather than the SANDAG targets.

Based on the current distribution of registered EVs in San Diego, Fehr & Peers has identified which jurisdictions will need to accelerate adoption policies most aggressively to meet the stated goals. Table 3.3 shows the share of regional population within each San Diego County jurisdiction, the share of regional VMT, the current number of EVs, the current number of vehicles, and the proportion of EVs as a share of each jurisdiction's vehicle population. Figure 3.3, following the table, shows the share of EVs as a proportion of all vehicles, by jurisdiction.

Table 3.3. Jurisdiction-level EV Population, Population Share, and VMT Share

Jurisdiction	Total # EVs (2020)	Total # Vehicles (including EVs) (2020)	Share % of Total Vehicles that are EVs (2020)	Total Vehicle Ownership Share % (2020)	Share of Regional Population (2019)	Share of Regional VMT (2012)
Unincorporated San Diego County	7,838	473,689	1.7%	16.9%	11.1%	15%
Carlsbad	3,804	92,092	4.1%	3.3%	3.5%	4.5%
Chula Vista	2,708	205,797	1.3%	7.3%	8.0%	5.7%
Coronado	395	12,727	3.1%	0.5%	0.7%	1.0%
Del Mar	861	13,358	6.4%	0.5%	0.4%	0.3%
El Cajon	1,183	126,488	0.9%	4.5%	5.2%	2.9%
Encinitas	2,318	51,148	4.5%	1.8%	1.9%	2.1%
Escondido	2,222	139,093	1.6%	5.0%	5.4%	4.5%
Imperial Beach	128	17,299	0.7%	0.6%	0.8%	n/a
La Mesa	967	54,751	1.8%	2.0%	2.2%	1.9%
Lemon Grove	145	20,861	0.7%	0.7%	0.8%	0.6%
National City	145	42,934	0.3%	1.5%	1.9%	1.7%
Oceanside	1,979	112,863	1.8%	4.0%	4.7%	4.3%
Poway	1,240	40,736	3.0%	1.5%	1.5%	1.9%
San Diego	25,337	1,179,150	2.1%	42.1%	43.1%	46.3%
San Marcos	1,876	73,657	2.5%	2.6%	3.0%	2.7%
Santee	544	44,691	1.2%	1.6%	1.7%	1.4%
Solana Beach	554	10,580	5.2%	0.4%	0.4%	0.6%
Vista	1,208	88,872	1.4%	3.2%	3.6%	2.6%
TOTAL	55,452	**2,800,786**	**n/a**	**100%**	**100%**	**100%**

Notes:

1. EV population and total vehicle population data from California Energy Commission (2020).
2. Population data from American Community Survey 5-Year Estimates (2015-2019), extracted by zip code. Zip codes were classified into the 19 jurisdictions above per the County of San Diego Superior Court zip code directory. Zip codes whose geographic boundaries fell into multiple jurisdictions were reviewed using aerial imagery to determine land use and classified into the jurisdiction with the greatest overlap of urban use.
3. VMT data from SANDAG ABM1 (2012). Total VMT is calculated using the OD method at the TAZ level and then aggregated to the jurisdictional level, which may result in some double-counting of trips but overall reflects a reasonable proportional share of the County's VMT.

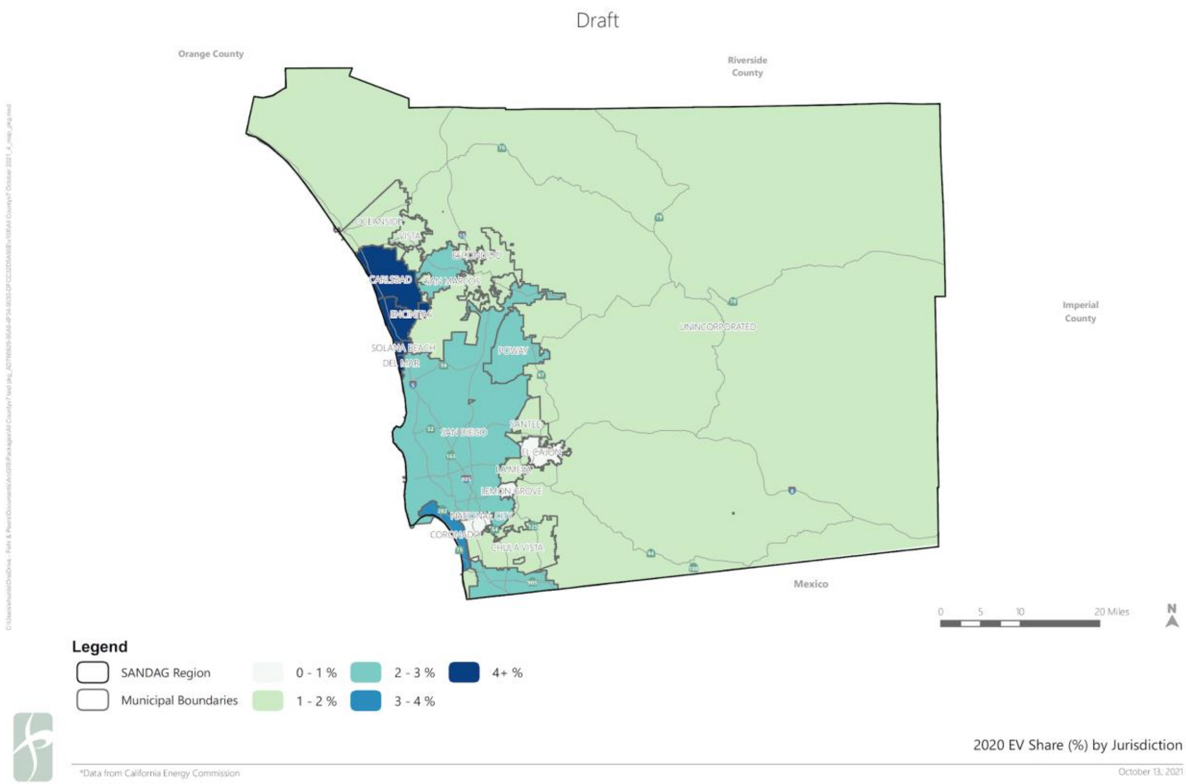


Figure 3.3. EV Share of All Vehicles, by Jurisdiction (2020). Source: CEC and Fehr & Peers, 2021.

In order to show where policy efforts can be focused to help accelerate EV ownership efforts, the Countywide 2030 EV targets can be downscaled to the jurisdictional level. Table 3.4 shows the future target number of EVs based on three alternative methods of calculation:

- Based on population share
- Based on VMT share
- Based on vehicle ownership share

There is no perfect way to downscale EV targets to the local jurisdictional level. Basing the future target on population would follow the A2Z approach to determining the target number of EVs in San Diego as a proportion of California's targets. However, this would produce an overestimated target in places where vehicle ownership rates are lower than average. Basing the future target on VMT would produce more aggressive targets in places where people drive longer distances. Basing the future target on vehicle ownership would reify the existing vehicle ownership patterns, which reflect the current inequities of EV ownership due to the cost of purchasing a vehicle as well as existing land use and travel behavior patterns. These travel patterns may change in the future as a result of future land use development patterns, encouraging more transit-oriented development (discussed further in the section to follow).

These downscaled targets are intended therefore to reflect a range of reasonable order of magnitude for each jurisdictions' EV population in 2030.

Table 3.4. Downscaled Jurisdiction Targets to Meet Regional A2Z EV Goals

Jurisdiction	Total # EVs (2020)	Future Target # EVs Based on Population Share	Future Target # EVs Based on VMT Share	Future Target # EVs Based on Vehicle Ownership Share
Unincorporated San Diego County	7,838	116,612	115,286	130,397
Carlsbad	3,804	26,396	34,708	25,351
Chula Vista	2,708	62,772	44,209	56,652
Coronado	395	4,931	7,682	3,503
Del Mar	861	984	2,402	3,677
El Cajon	1,183	24,074	22,334	34,820
Encinitas	2,318	14,340	16,486	14,080
Escondido	2,222	35,285	34,983	38,290
Imperial Beach	128	6,470	n/a	4,762
La Mesa	967	13,829	14,320	15,072
Lemon Grove	145	6,117	4,366	5,743
National City	145	14,320	13,280	11,819
Oceanside	1,979	40,895	32,828	31,069
Poway	1,240	11,378	15,024	11,214
San Diego	25,337	329,880	357,089	324,596
San Marcos	1,876	22,417	20,779	20,276
Santee	544	13,375	11,088	12,303
Solana Beach	554	3,191	4,248	2,912
Vista	1,208	23,736	19,890	24,465
TOTAL	**55,452**	**771,000**	**771,000**	**771,000**

Note: Percentages from Table 3.4.2 multiplied by A2Z's Countywide target of 771,000 EVs to determine jurisdictional targets.

To support the local acceleration of EV adoption towards the targets identified above, it will also be necessary to accelerate the rollout of EV charging infrastructure. The County and SANDAG can enhance the Plug-In San Diego Electric Vehicle Charging Map to provide improved modeling for charging infrastructure location suitability at a regional scale.[x] SANDAG and the County can collaborate with local jurisdictions to encourage them to undertake a local EV

[x] The Plug-In San Diego EV Charging Stations Map can be found at https://evcs.sandag.org/, which includes methodological information about how the TAZs were analyzed to identify EV trip end percentiles.

Infrastructure Siting Plan, to identify more granular placement locations, and to support infrastructure investments in Communities of Concern.

Policy Opportunity Areas

Jurisdictions within the San Diego region have a great deal of room to strengthen policies related to transitioning to EV fleets and providing sufficient charging infrastructure. Based on the summary of efforts described in the Regional Policy Context section of this chapter, along with the findings from the A2Z Gap Analysis, there is a wide variety of policies and actions that have been informally or formally adopted by jurisdictions across the San Diego region, which range from more encouragement-based to more requirement-based. There is also variation in how these policies apply to different types of land use and development. The variety of policies and actions are summarized in Figure 3.4.

Policies shown on the left of Figure 3.4 – for example, adopting a policy to provide EV chargers in lots that are owned by the jurisdiction – will not be sufficient to meet aggressive EV adoption goals. In contrast, policies shown on the right of Figure 3.4 – for example, those that require private developers to install chargers at a high percentage of their parking spaces, across all land use types (commercial, residential, etc.), at new development and retrofitting infill sites, with additional support for multi-family and communities of concern – would be substantially more effective at meeting aggressive EV adoption goals.

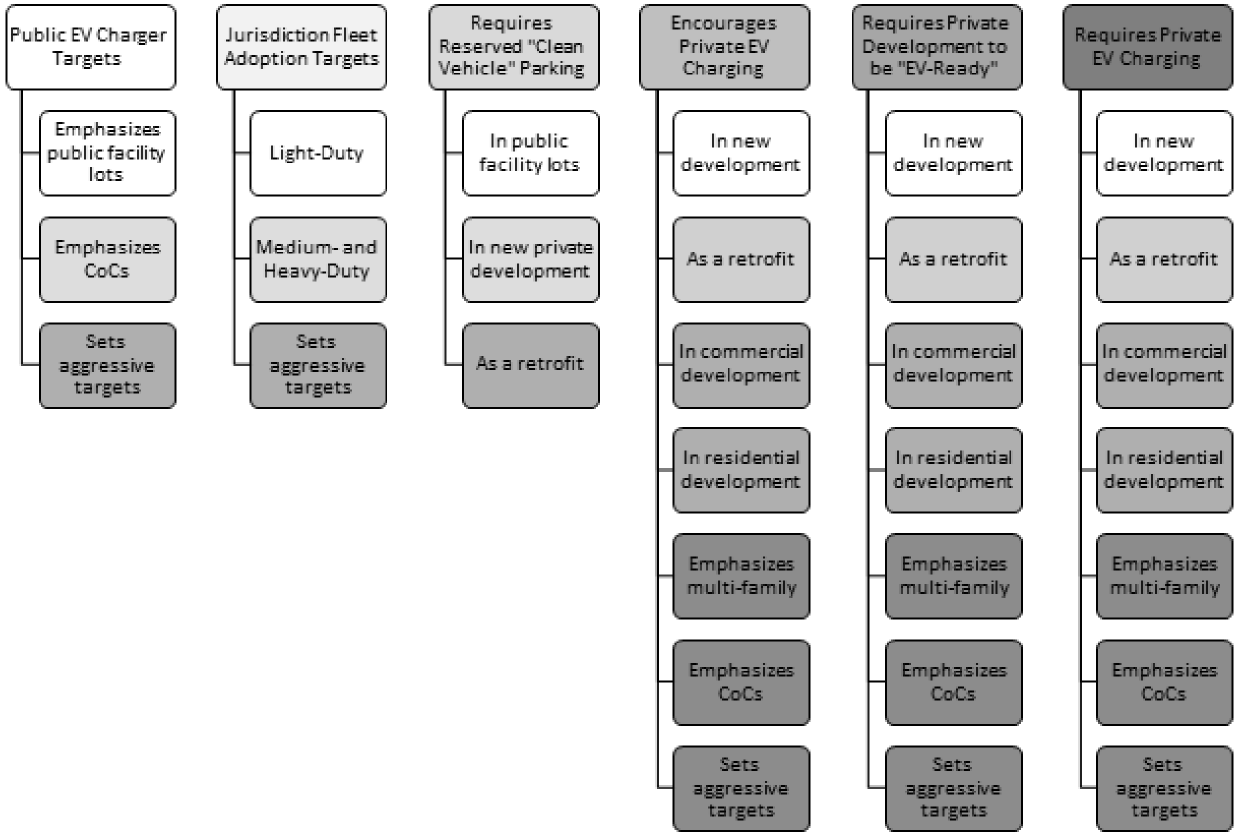


Figure 3.4. Policy Options to Accelerate EV Adoption.

In order to accelerate decarbonization most aggressively, the County can consider moving its own policies along the spectrum from more encouragement-based to more requirement-based, and by expanding the reach of requirements and ordinances to cover more land use contexts. To support the accelerated adoption of the strongest and most effective policies, the County can offer more appealing incentives, streamline development processes and infill benefits, and provide readily accessible information for property owners and vehicle owners. For areas where it does not have direct jurisdictional control or where collaboration across sectors is required, the County can partner with other entities to support workforce development goals, continue to collaborate across the region to share information and lessons learned, and support state-level advocacy to bring implementation funding to San Diego County. Table 3.5 summarizes ways in which the County can implement these actions and policies within the region or partner to make progress where the County lacks jurisdictional authority.

Table 3.5: Electrification Strategies and County Implementation Approach

Strategy	Partnership Opportunity	County Implementation Approach
Set Public EV Charger Target	✓	Update 2019 EV Roadmap to include more aggressive targets; continue to partner with A2Z Collaborative to downscale jurisdictional targets on appropriate roadways; identify partnership opportunities with those jurisdictions that have made the least progress toward their targets to share information and successful implementation strategies
Set Fleet Adoption Target	✓	Update 2019 EV Roadmap to include more aggressive targets; identify partnership opportunities with those jurisdictions that have made the least progress toward their targets to share information and strategies to accelerate fleet transition
Set-Aside Public Parking Spots for Clean Vehicles		Adopt requirements in County zoning code
Encourage EV Charging Infrastructure at Development Projects		Encouragement through incentives can complement stronger policy requirements where no County jurisdictional authority exists
Require New Development to be "EV-Ready"		Adopt requirements in County zoning code; adopt ordinance that requires retrofitting
Require EV Charging Infrastructure to be Installed at Developments		Adopt requirements in County zoning code; adopt ordinance that requires retrofitting
Offer Consumer Incentives to Purchase EVs	✓	Partner with SANDAG to accelerate and increase the amount of incentives, reduce barriers to accessing incentives, and promote aggressively in CoCs
Provide Readily-Accessible Information to Property Owners and Vehicle Owners	✓	Partner with private entities to understand information gaps; partner with SANDAG to produce coordinated educational materials and aggressively promote
Train Workforce to Support EV Ecosystem	✓	Partner with educational institutions to develop workforce training needs; increase funding to existing programs
Collaborate to Share Information Across Region	✓	Continue to partner with A2Z Collaborative
Engage in State-level Advocacy to Bring Implementation Funds to San Diego County	✓	Continue to partner with A2Z Collaborative

Accelerate Reduction of VMT

Current San Diego region actions and policies to reduce VMT are articulated in the 2021 Draft Regional Plan across the 5 Big Moves and regional land use development policies. SANDAG is required to demonstrate how the region will reach targets by reducing VMT. As such, plans for the 5 Big Moves describe ways to influence behavior change and support denser land uses. To meet the targets, vehicle trips need to be replaced with biking, walking, transit, and shared rides. The Draft 2021 Regional Plan articulates the following strategies to reduce VMT:

- Complete Corridors support a greater variety of transportation options, and the initiative promises investments in infrastructure to make alternative transportation more attractive. Complete Corridors also employ congestion pricing as a tool for reducing demand and VMT during peak times.
- Flexible Fleets provide convenient and affordable alternatives to driving alone.
- Transit Leap calls for a multimodal high-speed, high-capacity, high-frequency transit network that appeals to people who otherwise drive alone. In the 5 Big Moves, SANDAG states that public transit will "continue to be the most efficient way to move many people," therefore reducing VMT.
- Mobility Hubs are communities with a high concentration of people, destinations, and travel choices. Higher density Mobility Hubs have a supportive mix of land uses that can help to encourage ridership and usage of the Transit Leap system. However, Mobility Hubs in less dense areas may rely on more motorized services in order to connect residents to transit and not reach the same VMT reductions.

Table 3.6 provides details on VMT-reduction strategies that would support acceleration of VMT reduction within San Diego County. For those strategies that rely on zoning changes, the County can only directly influence the zoning code within its own jurisdiction. For other jurisdictions, the County can support information sharing, evaluation to prove effectiveness of strategies, and inter-jurisdictional collaboration to encourage other jurisdictions to undertake similar zoning changes to encourage denser, more walkable, and more transit-oriented development.

Table 3.6: VMT Reduction Strategies and County Implementation Approach

Policy Strategy	Electrification Opportunity	County Implementation Approach
Expand geographic reach of bus and rail services in areas where development can support transit use	✓	Identify corridors with land use patterns that can support transit; partner with transit agencies to fund additional miles of transit service
Invest additional transit service hours in places where transit is productive and high occupancy, focused on infill locations	✓	Identify highest-performing transit corridors; partner with transit agencies to fund additional hours of transit service
Provide incentives and regulatory relief to facilitate higher density infill and transit-oriented development		Modify zoning code along transit corridors to allow denser development; streamline permitting process for developments along transit corridors; leverage parking reductions, density bonuses, and other incentives to encourage development in transit corridors
Disincentivize development in rural (or non-infill) areas that cannot support efficient transit use or multi-modal transportation options		Utilize transit opportunity areas, infill areas, and VMT efficiency metrics to encourage compact development and discourage exurban and very rural development
In existing rural, non-infill, or underserved transit areas, invest in TNC partnerships to ensure sufficient access to opportunities	✓	Identify limited-access areas that would benefit from additional mobility resources; develop TNC partnerships to support travel using higher-occupancy vehicles
Incentivize high occupancy personal vehicle use		Investigate opportunities to implement pricing structures (cordon pricing, HOT lanes, etc.) that incentivize high occupancy vehicles
Design walkable communities, particularly in places where compact development patterns are already established		Adopt pedestrian-oriented design guidelines for all new development; reduce or remove parking minimums in walkable neighborhoods
Expand pedestrian and bicycle facilities, using a network approach to ensure destinations are served, corridors and intersections are equally comfortable and safe		Update county bicycle and pedestrian planning documents; partner with SANDAG to accelerate implementation of 2010 San Diego Regional Bicycle Plan; develop Pedestrian Safety and/or Vision Zero and/or Local Road Safety Plan
Expand modal options including a wide range of e-bikes, e-scooters, bikeshare, micro transit, shuttles, and TNC partnerships	✓	Partner with SANDAG to build out network of Mobility Hubs where shared vehicles and new mobility services can be found

Conduct programs to ensure people of all abilities and ages are comfortable using bicycle and pedestrian facilities		Partner with mobility advocacy organizations to fund expanded education programming; implement periodic regular open streets events throughout the County
Encourage TDM programs that incentivize some proportion of telework, telemedicine, remote learning and use of transit		Develop County TDM ordinance and Transportation Management Organization (TMO) to work with employers and service providers
Expand broadband in places where it is weak		Conduct broadband gap analysis; seek funding to improve communications infrastructure in areas that lag; require enhanced communication technology in all new development through TDM ordinance
Restructure distribution centers to enable more efficient delivery patterns that enable short-haul electrified freight vehicles and AV delivery	✓	Conduct electrified freight study to understand where opportunities for distribution efficiencies exist; modify zoning code to encourage distribution centers in efficient locations

Geographic Opportunity Areas

The above strategies are likely to be successful in different locations across the County. Transit-oriented strategies will be most successful in places where the density of population and development can support efficient transit vehicle use, or ‘infill’ locations. Walking and biking strategies will likely be more effective in infill locations. In non-infill locations, strategies related to trip reduction through TDM, partnerships with TNCs that prioritize electrification and high-occupancy ridership, and enhancing broadband service may be more successful strategies to reduce VMT.

Figure 3.5 shows the transportation analysis zones (TAZ) in San Diego County that meet the following definition of infill:

- Household density above 385 housing units/square mile (selected based on the US Census definition for urban area)
- Intersection density above 128 intersections/square mile (matches Frost (2018) average value for ‘Urban Places’)
- Job Accessibility of 12.73 (average value for local employment accessibility in Salon (2014))

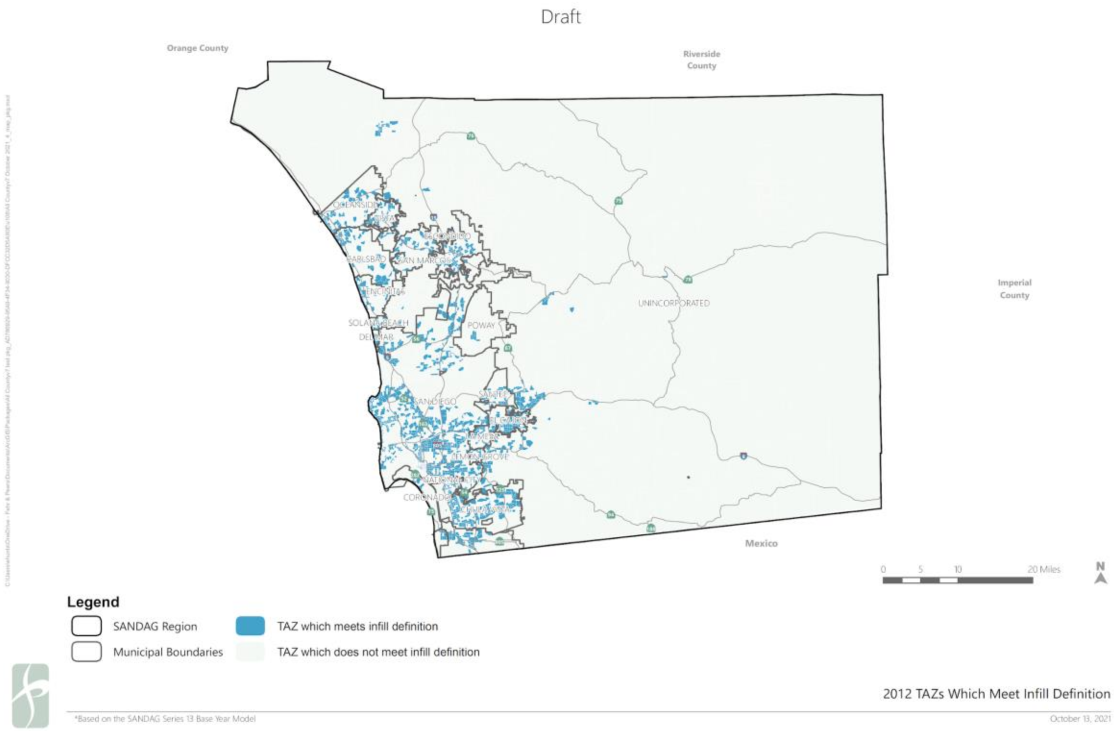


Figure 3.5. TAZs Which Meet Infill Definition. Source: SANDAG Series 13 Base Year Model (2012), Fehr & Peers, 2021.

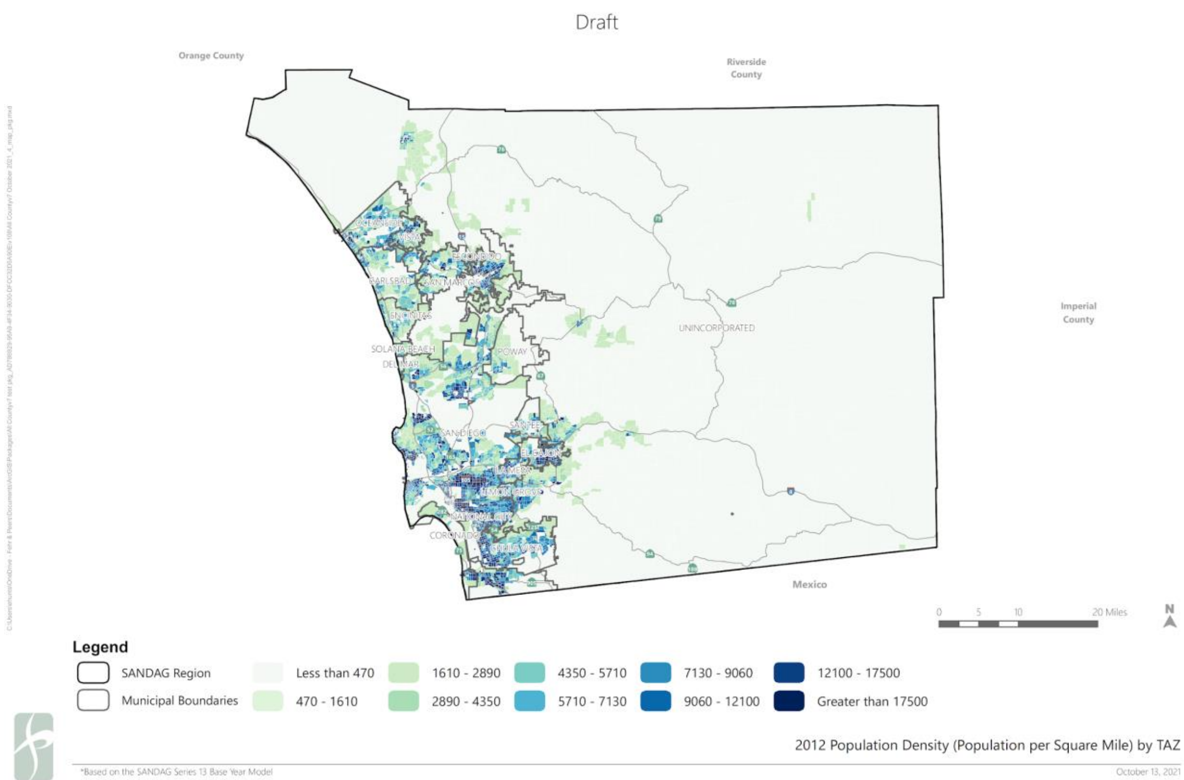


Figure 3.6. 2012 Population Density. Source: SANDAG Series 13 Base Year Model (2012), Fehr & Peers, 2021.

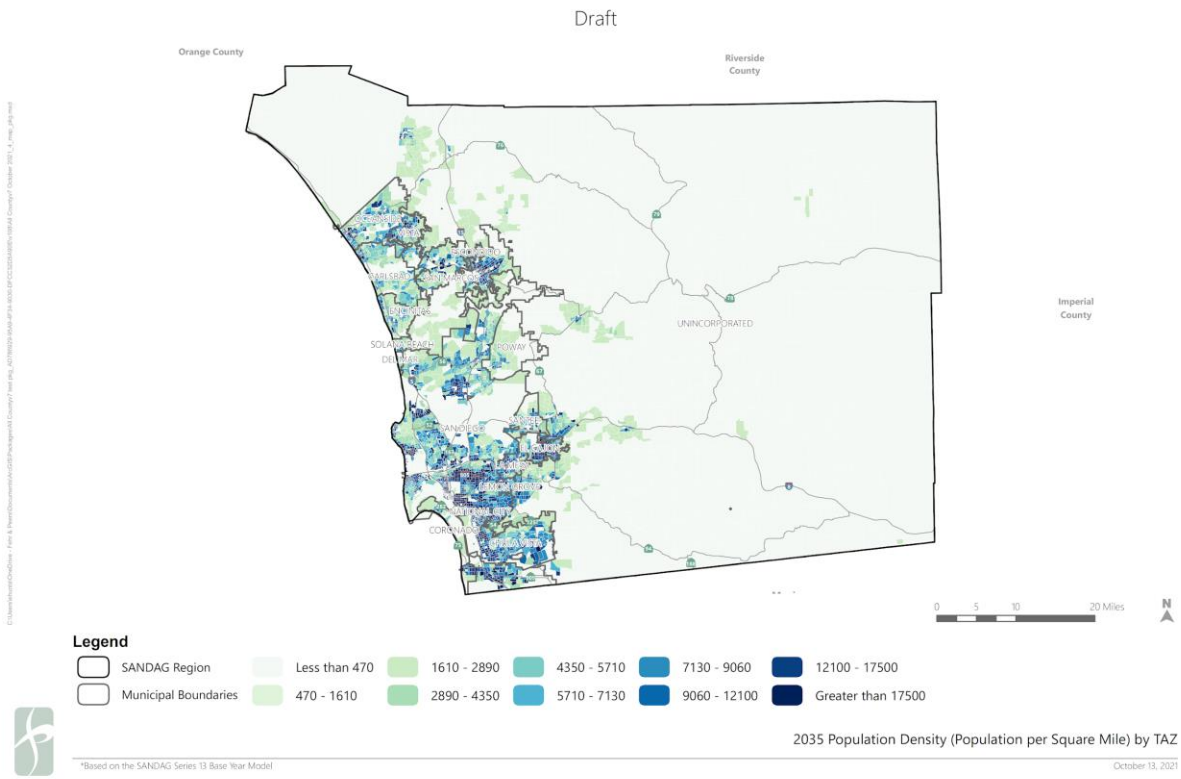


Figure 3.7. 2035 Population Density. Source: SANDAG Series 13 Base Year Model (2035), Fehr & Peers, 2021.

Over time, additional areas may become well-suited for infill-oriented VMT reduction strategies as they meet higher population density thresholds. Figures 3.6 and 3.7 show how population density is anticipated to change between 2012 and 2035, creating more opportunity for future expansion of infill-oriented and transit-oriented strategies.

3.5 Conclusion

This chapter shows where opportunity areas exist to accelerate EV adoption and VMT reduction based on existing countywide policies and patterns of vehicle ownership, travel behavior, and land use development. Recommended areas for accelerated action will help the County meet more aggressive decarbonization targets that have been established for California but are not yet satisfied in the guiding policies in the region. Following discussion with the County, the project team will conduct additional analysis to ensure the County has access to the most helpful information to guide their decisions and move towards deep decarbonization of the transportation sector.

Summary of Key Actions

Actions that will accelerate decarbonization of the transportation sector are largely grouped into two categories: electrification of vehicles, and reduction of VMT. The key actions that the County can pursue over the next 10 years to make progress towards deep decarbonization goals will include a mix of both strategies. As part of this Regional Decarbonization Framework, additional work will be conducted to identify which of these actions may already be underway, which are the highest priority to initiate, which geographic areas need more focus, where local jurisdictions have control, and where actions could benefit from regional coordination and collaboration.

Key electrification actions include:

- Set and meet aggressive public EV charging target
- Set and meet aggressive (100%) fleet adoption target
- Require new development to include EV charging
- Require existing development to retrofit parking with EV charging
- Increase dollar value and streamline consumer vehicle purchase incentives with application to both new and used vehicles
- Increase dollar value of incentives, provide educational resources, and streamline permitting process for landowners to install EV charging in multi-family developments
- Partner with educational institutions to assess workforce training needs; increase funding to existing programs
- Continue to partner with A2Z Collaborative to share information and successful implementation strategies across jurisdictions, advocate for funding and coordination at the state level

Key VMT reduction actions include:

- Expand geographic reach and service hours of bus and rail services in areas where development can support transit use
- Provide incentives and regulatory relief to facilitate higher density infill and transit-oriented development
- Disincentivize development in rural (or non-infill) areas that cannot support efficient transit use or multi-modal transportation options
- In existing rural, non-infill, or underserved transit areas, invest in TNC partnerships prioritizing electric and high-occupancy vehicles to ensure sufficient access to opportunities
- Investigate opportunities to implement pricing structures (cordon pricing, HOT lanes, etc.) that incentivize high occupancy vehicles

- Adopt pedestrian-oriented design guidelines for all new development; reduce or remove parking minimums in walkable neighborhoods
- Update county bicycle and pedestrian planning documents; partner with SANDAG to accelerate implementation of 2010 San Diego Regional Bicycle Plan; develop Pedestrian Safety and/or Vision Zero and/or Local Road Safety Plan
- Partner with SANDAG to build out a network of Mobility Hubs where shared vehicles and new mobility services can be found
- Develop County TDM ordinance and Transportation Management Organization (TMO) to work with employers and service providers
- Conduct broadband gap analysis; seek funding to improve communications infrastructure in areas that lag; require enhanced communication technology in all new development through TDM ordinance
- Conduct electrified freight study to understand where opportunities for distribution efficiencies exist; modify zoning code to encourage distribution centers in efficient locations

Additional Challenges & Remaining Gaps Not Addressed in this Chapter

Additional challenges and major gaps remain which will require collaboration, coordination, and technical advances to vehicle stock beyond what exists on the road today. In addition, outstanding questions regarding environmental externalities are important to consider as the County accelerates towards electrification as the primary means to decarbonize the transportation sector. These challenges and gaps that the County should consider include:

- Coordination with tribal jurisdictions in order to maximize decarbonization efforts county-wide
- Technology advances and limited jurisdictional control for influencing long-haul intercity passenger travel, including air travel and border crossings
- Long-haul freight technology and jurisdictional control
- Environmental externalities of electrification (waste, pollution, etc.)
- Vehicle production emissions, roadway maintenance emissions
- Lifestyle changes in the future that may not be reflected in today's forecasts or assumptions (work from home patterns, home delivery of goods, suburban migration)
- Policy response to pandemic conditions by transit agencies in order to match service to lower ridership levels, or to attempt to recover lost ridership

The above considerations are worthy of additional study.

Table 3.7: Comparison of SANDAG 2021 Regional Model (ABM2+) and EnergyPATHWAYS Model

Model	**Fleet Mix Assumptions**			**Fuel Mix Assumptions**	
	Passenger Cars and Trucks	Transit Vehicles	Commercial Vehicles	ZEV Adoption Rate (Passenger and Goods)	Speed
SANDAG 2021 Regional Model (ABM2+)	5 classes for traffic assignment: - Drive-alone non-transponder - Drive-alone transponder - Shared-ride 2 - Shared-ride 3+ - Heavy Truck Each class is broken down by income or by weight class for a total of 15 traffic assignment classes.	7 transit modes: - Tier 1 Heavy Rail - Commuter Rail - Light Rail - Streetcar - Rapid Bus - Express Bus - Local Bus Inputs vary by mode: - Frequency of service - Travel time - Fare	5 goods movement modes: - Truck - Rail - Pipeline - Marine - Air cargo 4 commercial truck types: - Light vehicle - Medium truck (<8.8 short tons) - Medium truck (>8.8 short tons) - Heavy truck (FHWA classes 7-13)	Zero Emission Vehicles (ZEV) and Electric Vehicles (EV) in general are handled off-model. Growth forecasts are based off EMFAC. Between Model Year (MY)2025-2050, required percent of new Light Duty Vehicle (LDV) sales that must be ZEVs in EMFAC2017: - Plug-in Hybrid Vehicles (PHEV): 7.32% - Battery-Powered Electric Vehicle (BEV): 4.06% - Hydrogen Fuel-Cell Electric Vehicle (FCEV): 14.89% PHEV, BEV, FCEV are all referred to as ZEVs.	Inputs that affect speed on regional highway networks: - Posted speed - Roadway capacity - Functional classification - Roadway operation (HOV lane, etc.) - Congestion - Origin/destination - Intersection control - Transportation mode
Evolved Energy Model (EnergyPATHWAYS)	- Light car - Light truck - Motorcycle	- Buses - Passenger Rail	- Medium truck - Heavy truck (divided into short haul and long haul)	EMFAC growth forecasts. Different assumptions by class: more BEV for HD short haul truck, more FCEV for HD long haul.	n/a

Model	VMT Accounting			Resolution	
	Method	Scale	Conversion to GHG	Spatial	Temporal
SANDAG 2021 Regional Model (ABM2+)	Accounting Methods for GHG calculations using Vehicle Miles Traveled (VMT): - Internal-Internal: all VMT included in analysis (VMT that occurs from trips that start and end in the SANDAG region) - Internal-External or External Internal: 50% of VMT included in analysis (VMT associated with trips with one trip end in the SANDAG region and one outside the SANDAG region) - External-External: all VMT excluded in analysis (VMT associated with trips that start and end outside of the SANDAG region are not included).	- Total VMT and GHG and per-capita VMT and GHG.	VMT data tables are used within EMFAC for emissions calculations of cold starts (trips) and running emissions (VMT). Calculations are adjusted by transportation activity data (VMT, speed distribution) and vehicle populations. Emissions reductions associated with various ZEV policies also calculated outside of the travel demand model.	Different resolution levels for different steps of the model: - Microanalysis zones: 23,002 Master Geographic Reference Area (MGRAs) zones (roughly equivalent to Census blocks) - Traffic assignment demand and skims: 4,996 Transportation Analysis Zones - Transit assignment demand and skims: 1,766 Transit Access Points Treatment of space is slightly different for border crossing trips.	Transportation behavior is modeled every half hour.
Evolved Energy Model (EnergyPATHWAYS)	n/a	n/a	Electricity and fuel emissions intensities determined by supply-side optimization subject to net-zero economy-wide constraints.	Vehicle stock is modeled for Southern California region (divide from Northern California is along PGE/SCE service boundary). Number of households is used to estimate vehicle stock.	Annual vehicle stock.

Model	Analysis Years		Input Data	
	Base Year	Horizon Year	Internal (SANDAG) Surveys	Outside Data Sources
SANDAG 2021 Regional Model (ABM2+)	2016	2050	- SANDAG Household Travel Behavior Survey (2016) - Transit On-Board Survey (2015) - SB 1 Transportation Network Company (TNC) Survey (2019) - Taxi Passenger Survey (2009) - Parking Inventory Survey (2010) - Parking Behavior Survey (2010) - Border Crossing Survey (2011) - Visitor Survey (2011) - Establishment Survey (2012) - Tijuana Airport Passenger Survey (2017) - Commercial Vehicles Survey (2011) - Vehicle Classification & Occupancy (2006)	- San Diego International Airport Air Passenger Survey (2009) - San Diego International Airport Passenger Forecasts (2013) - Decennial Census Summary File-1 tabulation (2010) - Census Data for Transportation Planning (CTPP) - Public Use Microdata Sample (PUMS) - American Community Survey (2015-2017) - Bicycle counts (2011) - Jurisdiction annual traffic counts (2016) - FasTrak Transponder ownership data (2012) - Caltrans Performance Measurement System (PeMS) (2016) - Caltrans Highway Performance Monitoring System (HPMS) (2016)
Evolved Energy Model (EnergyPATHWAYS)	n/a	2050	n/a	- University of Virginia Population Projections - California Air Resources Board vehicle service numbers (EMFAC) - 2021 US Annual Energy Outlook

Works Cited

1. SANDAG. 2021 Regional Plan Programs and Policies - Electric Vehicles. https://sdforward.com/docs/default-source/2021-library/5335-rp-policyonepagers-08electricvehicles_final_en.pdf?sfvrsn=e9b4fe65_2 (2020).
2. SANDAG. 5 Big Moves. San Diego Forward https://www.sdforward.com/mobility-planning/5-big-moves (2021).
3. Black & Veatch Management Consulting. San Diego Regional Electric Vehicle Gap Analysis. https://www.sdge.com/sites/default/files/2021-07/FINAL%20San%20Diego%20Regional%20EV%20Gap%20Analysis%20%281%29.pdf (2021).
4. County of San Diego. County of San Diego Electric Vehicle Roadmap. https://www.sandiegocounty.gov/content/dam/sdc/sustainability/EV-Roadmap/EV-Roadmap-October-2019.pdf (2019).
5. County of San Diego. County of San Diego Climate Action Plan - Final. https://www.sandiegocounty.gov/content/dam/sdc/pds/advance/cap/publicreviewdocuments/PostBOSDocs/San%20Diego%20County%20Final%20CAP.pdf (2018).

4. Natural Climate Solutions and Other Land Use Considerations

Elise Hanson, UC San Diego
Emily Leslie, Montara Mountain Energy

Key Takeaways

- Natural climate solutions are an important component of decarbonization because they involve natural sequestration and medium to long-term storage of carbon dioxide in lands, but natural climate solutions alone cannot generate enough negative emissions in the San Diego region to achieve net zero emissions.
- To reach net zero, natural and working lands need to act as stronger *net* sinks than they currently do, which means investment in natural climate solutions and minimizing carbon emissions from the land. In order to accurately account for net carbon land use emissions, local data need to be collected and integrated into regional carbon calculations.
- The most effective and most inexpensive natural climate solution in the San Diego region is to avoid land use change; however, this is neither feasible nor desirable because land use change will be important for other decarbonization actions, like siting renewable energy infrastructure.
- Other important regional natural climate solutions considered here are less effective and more expensive and include carbon farming, wetland protection and expansion, and urban forestry. Other solutions are large-scale habitat restoration and reforestation, which is expensive and may not be effective.
- The natural climate solutions considered here include co-benefits of ecosystem services (e.g., water and air quality improvements, ecological resilience, biodiversity protection) and economic, social, and public health benefits (e.g., energy savings and localized public health improvements from increased urban tree cover) that may help justify the cost of natural climate solutions, even in circumstances where carbon sequestration and storage may be relatively low.

4.1 Executive Summary

This document provides an overview of the natural climate solutions available for the San Diego region and for governments within the region. The opening part of this document reviews the ecological context and introduces terminology (for example, making the distinction between carbon *sequestration* as a process and carbon *storage* as an accumulated quantity). It also introduces overarching concepts and themes (the effect of land use change on carbon sequestration and storage, and the co-benefits of natural carbon sequestration measures). The latter part of this document reviews a range of natural carbon sequestration measures available to regional governments like the County Board of Supervisors: land use change, agriculture, blue carbon, and urban trees and forestry. There is a section detailing an analysis, discussion, policy implications, and policy recommendations for each of these measures.

Based on the analysis presented here, we conclude that the simplest, most effective, and least expensive of the solutions is to continue to protect and preserve natural and working lands because these lands sequester and store carbon naturally. The conservative estimates herein suggest that regional carbon storage is high (approximately 58 million metric tons of carbon dioxide equivalent (MMT CO_2e) in plants, trees, leaf litter, and soil) and that annual sequestration is significant (over 2 MMT CO_2e per year). The most important lands to protect are those with the highest storage and sequestration potential (such as the scrub and chaparral ecosystems throughout the county, which have the greatest total carbon storage potential overall, and coastal wetlands, which have the greatest storage potential per hectare), as well protecting those lands with the highest co-benefits (such as air and water quality improvements, biodiversity protection, and public health outcome improvements).

Other important solutions considered in this report are to:

1) research and incentivize carbon farming techniques like compost application, riparian restoration, and orchard tree retention,
2) restore wetlands and surrounding areas, and
3) increase urban tree canopy cover.

Additionally, regional governments should utilize the most recent and localized data possible when estimating natural climate solutions’ contributions to decarbonization. These localized data are crucial because inaccurate data can lead to overestimating net negative emissions, thus leading to falling short of net zero goals, or underestimating net negative emissions, thus leading to inefficiencies or higher costs incurred in other sectors contributing to net zero goals. Further, the uncertainties surrounding carbon cycling under droughts, wildfire recovery, or unseasonable rain compound the existing uncertainties of carbon accounting under normal conditions and justify better, more localized data. Several studies of local chaparral and blue carbon storage and sequestration are currently underway and these data will be critical to understanding and valuing regional land contributions to negative emissions and long-term carbon storage.

Finally, governments in the region - including the County of San Diego, city governments, tribal governments, and federal agencies - should quantify economically and socially important ecosystem service co-benefits provided by natural and working lands, carbon farming, blue carbon, and urban forestry. In particular, co-benefits like water savings, ground water recharging, air and water quality improvements, equity improvements, property damage reductions from storm surges and other natural phenomena, biodiversity protection, climate and other refugia protection, and wildfire prevention should be considered, quantified, and maximized in addition to carbon sequestration and storage.

4.2 Introduction

San Diego region's ecology

The San Diego region and the larger California Floristic Province are generally considered "biodiversity hotspots," or areas characterized by high levels of endemism and habitat intactness while facing threats of extinction or biodiversity loss.[1–3] San Diego County is widely regarded as the most biodiverse county in the nation, in large part due to its high diversity of plants, native bees, birds, reptiles, and mammals,[2,4–7] and the region is characterized by being largely shrub-dominated, having cool, wet winters with warm, dry summers, and having highly fragmented habitats near urban and suburban development (Figure 4.1; Table 4.1).[2,8] The San Diego region is also home to over 70 species that are listed as either threatened or endangered at either the state or federal level and over 100 more species that are considered to be at-risk.[9] Further, the San Diego region contains areas that are considered refugia - or areas that are relatively protected from stressors that can negatively affect species or ecosystem survival - from fire, climate change, water stress, and recreational impacts.[10] These regions will be increasingly important for maintaining ecosystem functioning and for protecting ecosystem services, like carbon storage,[10,11] thus highlighting the importance of land use planning at the ecosystem level across the entire region.[12,13]

Natural climate solutions

Land use and land use change contribute to both negative and positive emissions in the San Diego region, though the emissions are generally net negative and therefore mean that lands are carbon sinks (Figure 4.2).[12,14,15] Land management practices and natural resource uses can maintain, increase, or decrease negative emissions and therefore affect the associated strength of the land as a carbon sink accordingly. Those actions which maintain or increase negative emissions and bolster carbon sinks are commonly known as natural climate solutions.[12,16,17]

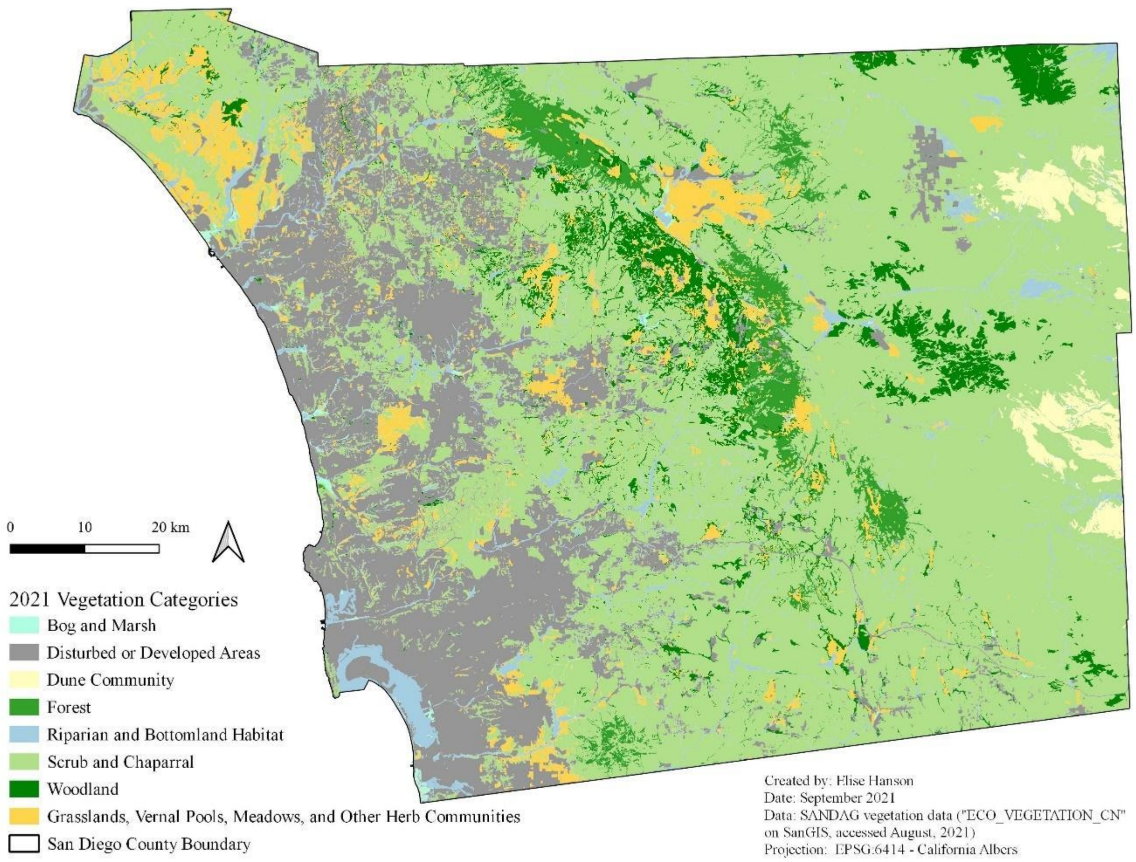


Figure 4.1. Vegetation categories within the San Diego County boundary. All data from SanGIS (SanGIS.org). Agricultural lands are categorized as "Disturbed or Developed Areas."

Table 4.1. Areas (km^2) and percent of total areas in the San Diego County boundary per vegetation category and total areas and percentages of total areas per vegetation category that are conserved, calculated in QGIS 3.16 from Figure 4.1.

	Regionwide totals		Conserved land totals	
Vegetation Categories	Area (km^2)	Percent	Area (km^2)	Percent
Disturbed or Developed Areas, including Agriculture (pasture, orchards, row crops, etc.)	2218.226	20.100	95.887	4.323
Dune Community	190.471	1.726	181.547	95.315
Scrub and Chaparral	6503.742	58.932	4234.537	65.109
Grasslands, Vernal Pools, Meadows, and Other Herb Communities	655.067	5.936	182.41	27.846
Bog and Marsh	25.289	0.229	15.142	59.876
Riparian and Bottomland Habitat, including open water, bays, and freshwater	415.411	3.764	193.742	46.639
Woodland	681.826	6.178	355.519	52.142
Forest	345.971	3.135	172.787	49.943
TOTAL	**11036.003**	**100%**	**5431.571**	**49.217%**

Natural climate solutions will play a significant role in removing and storing atmospheric carbon dioxide. One study suggests that terrestrial and coastal lands and associated natural climate solutions could contribute up to 30% of the mitigation needed in 2050 to keep warming to 1.5 degrees.[18] This finding, and others, demonstrate the importance of maintaining and enhancing ecosystem carbon sequestration. The finding also underscores the fact that other mitigation and negative emissions technologies will be needed to offset natural and anthropogenic emissions.[xi; 12,16,18–20] In other words, natural climate solutions are not a panacea.

[xi] It is worth noting that the degree to which natural climate solutions are needed will depend on other factors in decarbonization. For example, in the Evolved Energy Research (EER) model technical appendix (Appendix A of this report), the "No Sequestration" model, which assumes no carbon capture and sequestration of fossil fuel combustion energy sources, would require less natural sequestration because it would rely more heavily on renewable energy production rather than fossil fuel production.

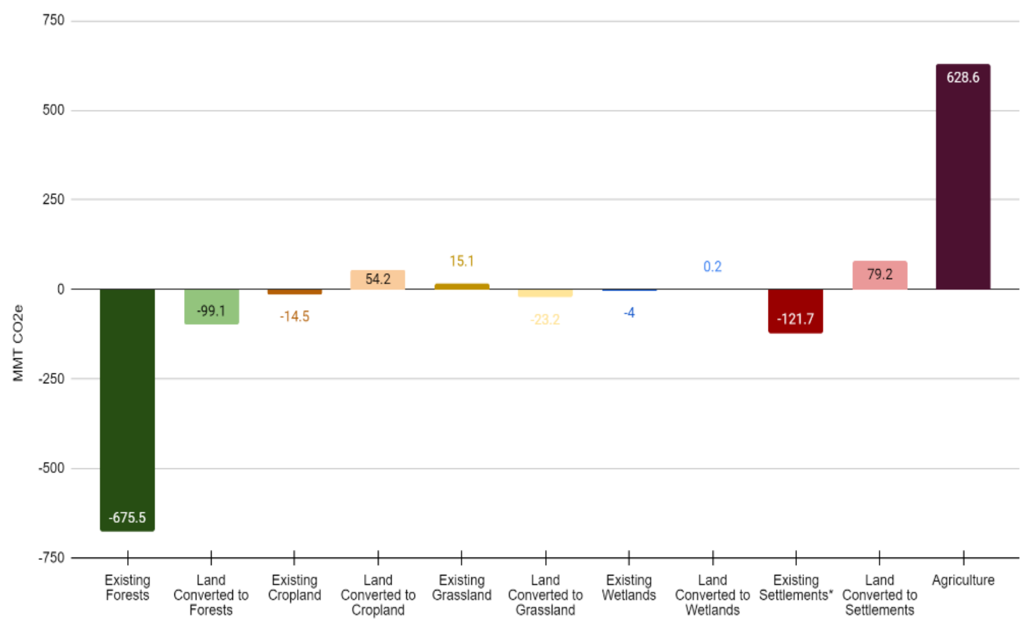


Figure 4.2. Total 2019 natural and working lands carbon dioxide equivalent (CO_2e) net emissions per land use and land use change sector and for total forestry and total agricultural sectors in the United States. Negative values are net negative emissions, or sequestration, and positive values are net positive emissions. Data are from the 2021 EPA report of national greenhouse gas emissions, tables 5-1 and 6-1.[15] *The "existing settlements" sector includes urban trees, which offer large sequestration gains. Without urban trees, existing settlements would have net positive emissions.

Globally, nationally, and in California, most of the natural mitigation will occur through reforestation, afforestation, forest management, agroforestry, and other tree-based solutions.[12,18,21,22] The San Diego region is shrub-dominated[2] (Figure 4.1), so there are fewer tree-based natural climate solutions beyond restoring riparian areas and increasing the urban tree canopy cover.[12,17] Instead, local natural climate solution such as non-forest management of shrublands and shrubland restoration may be important, despite not being important globally.[12] These warrant further research but are not considered in this report.

There are two major considerations for land use and natural climate solutions in the San Diego Regional Decarbonization Framework: 1) maintaining or increasing annual greenhouse gas (GHG) sequestration in natural and working lands and 2) decreasing or maintaining potential GHG emissions from the land and coastal ecosystems after a disturbance or land use change. This analysis focuses on net carbon dioxide equivalent (CO_2e) emissions of land use and natural climate solutions, though it is important to note that there are numerous co-benefits associated with land use management and natural climate solutions including, but not limited to:

biodiversity and endemism conservation, natural resource availability, ecological resilience, ecosystem services, and more.

Sequestration

Carbon sequestration is the flow of carbon dioxide from the atmosphere into soils, biomass, geological formations, etc. Natural and working lands, the latter of which includes agricultural lands, like orchards, plant nurseries, row crops, and pasture lands, can sequester carbon dioxide through photosynthesis and can sequester methane and nitrous oxide through bacterial metabolic reactions,[23–25] though natural and working lands tend to be sources of methane and nitrous oxide rather than sinks.[24,26–28] Natural and working lands, as opposed to settlements or other built up areas, therefore can act provide net negative emissions and counteract some GHG emissions in other sectors.[20,21,24] Given that natural lands tend to only have net negative emissions of carbon dioxide, this report will focus on methods to sequester carbon dioxide annually.

Annual carbon sequestration rates vary by prevailing climate, disturbance, and dominant plant species,[29] as will be described in some detail in section 4.3, but generally landscapes with older, more photosynthetic biomass, or tissues and other materials from plants that are or were a part of an organism, have higher sequestration rates.[29,30] As such, forests tend to have higher sequestration rates than grasslands, for instance, with forests being able to sequester up to twice as much carbon as grasslands.[20,21,24] While the emphasis is often on simply planting trees, the International Panel on Climate Change's most recent report highlights the scientific consensus that afforestation, or planting trees in lands like grasslands or savannas that historically did not have any or many trees, should be avoided, as it replaces native and adaptive vegetation with ill-adapted trees and is therefore more vulnerable to carbon emissions and provides fewer co-benefits.[20,31] Further, the report emphasizes that the type of tree matters[20,32] and that non-forest ecosystem protection and restoration are also critical.[20]

Storage

Natural and working lands hold large quantities of carbon in both biomass, living and dead, and in soils.[21,24] Carbon storage is an accumulated stock of carbon dioxide stored as carbohydrates and other carbon-containing molecules. Carbon storage in plant tissues occurs when net primary production (NPP) is positive, which is when carbon sequestration occurs. Primary production is the process by which photosynthetic organisms create sugar and oxygen via water and carbon dioxide. NPP is the sugar creation minus the carbon dioxide released through respiration. When NPP is positive, the plant sequesters more carbon dioxide through sugar production than in releases through respiration.[13–15] As plants grow, they store carbon in their tissues in both aboveground (e.g., stems, leaves, trunks) and belowground (roots) biomass. The fate of that carbon is highly dependent on local conditions, however, generally, some belowground biomass will become soil carbon as the root tissues die and are partially decomposed. Aboveground biomass can store carbon in the system as dead/downed woody debris. This storage is especially important in low humidity systems where decomposition rates are lower, as they are in Southern California.

Despite the fact that natural systems are adept at storing carbon on average and in the long-term, there is large variability by ecosystem type in the San Diego region. For instance, though forests and woodlands store and sequester more carbon globally, they play a smaller role in Southern California. This is largely due to the relative lack of forests in the San Diego region (Figure 4.1, Table 4.1), but is also due to the fact that existing trees and forests grow more slowly in the majority of Southern California than in more humid regions.[13,17,22]

Similarly, the San Diego region is dominated by shrubs and other woody, non-tree plants, as nearly 60% of the region is classified as scrub or chaparral habitats (Table 4.1), which are locally important for carbon storage[2,12,30] and for nitrogen storage.[33] Scrub habitats, including coastal sage scrub (CSS) and chaparral, are somewhat unique in that they continue to provide high sequestration rates and storage even when they are invaded by non-native grasses, which are themselves inefficient carbon storage systems.[33] Further, because Southern Californian scrub-dominated ecosystems have longer historic fire regimes than forest-dominated or more northerly regions,[34–37] San Diego's scrub ecosystems have low carbon "turnover" from their dead, woody tissues.[33]

Though marsh and wetland ecosystems are slow to sequester carbon on an annual basis, they hold large quantities in stable reserves[38,39] and can even transport some carbon to the deep ocean, thereby storing it for millennia or longer.[40] For California, salt marshes, salt pans, mudflats, and seagrass beds are the crucial "blue carbon" ecosystems that store marine carbon.[39,41,42]

Preventing emissions from land use change

Avoided emissions are those emissions that would come from natural and working lands if not for some protection or prevention. In California, the majority of avoidable emissions come from large-scale, crown wildfires in forests and from land use change in forests, shrub, wetlands, grasslands, and agriculture (roughly in that order) from natural to human-made environments.[12,13,43] In the case of wildfires, centuries of fire suppression have left areas with excess downed woody debris on the forest floor, which fuels faster, hotter fires.[36] Additionally, pest and noxious weed invasions have fueled large, destructive fires, even in the face of forest management, by creating larger pools of downed woody debris through tree die-offs and swaths of dead grasses or excessively flammable leaf litter, respectively.[36,44] Further, worsening droughts reduce the likelihood that a healthy forest or scrub will withstand a wildfire and drastically reduce the likelihood that an invaded forest or scrub will withstand a wildfire.[12,36,44] This was the case in San Diego's 2003 and 2007 super fires, where large quantities of dead pine trees, oak trees, and annual grasses fueled historic fires and permanently altered ecosystems.[35,44] In the case of land use change, rapid development has fragmented the San Diego region's natural ecosystems and created large expanses of settled and built up areas that provide little carbon sequestration value.[2,8,13,15]

Additional future emissions will occur with sea level rise. As seawater inundates intertidal zones, marshes, bogs, and wetlands, the associated plants will die and the carbon stored in the sediment and biomass will be emitted.[42] These emissions will be unavoidable,[45,46] but they can be mitigated through restoring upland habitats and allow for wetland migration, which would hypothetically result in net zero emissions from wetland loss due to sea level rise.[17,42,47,48]

Other considerations (co-benefits)

Natural and working lands provide numerous societal benefits as a result of natural ecosystem processes. These ecosystem services include air and water quality improvements, reduced impacts from natural disasters, increased food and fiber production, groundwater recharging, increased biodiversity and ecological resilience, and improved public health. The majority of the proposed methods to increase carbon storage and sequestration naturally have co-benefits.[17,20–22,49] For the natural climate solutions considered in this report, each is reported by the California Air Resources Board (CARB) to improve water quality and/or increase water quantity; protect biodiversity, habitats, and ecosystem health; and improve public health and/or community resilience to climate change. Additionally, protecting natural and working lands from land use change, urban forestry, and chaparral restoration improve air quality.[49]

While this report focuses on the carbon storage and sequestration aspects of natural climate solutions, it will be important to characterize, quantify, and monetize the additional ecosystem services and co-benefits in the future in order to understand the full impacts of these solutions.

The rest of the report will focus on four natural climate solutions that are implementable for the San Diego region and that would create negative emissions, maintain or increase carbon storage, and provide co-benefits. These four natural climate solutions are: protection of natural lands from land use change; carbon farming; protection of blue carbon; and urban forestry.

4.3 Land use change

Introduction

Natural and working lands are carbon sinks and are globally recognized for their ability to sequester and store carbon dioxide in plant biomass and soils.[14,20] The current level of net negative emissions from natural and working lands is insufficient to offset anthropogenic emissions, however they represent an important tool for reaching net zero emissions globally, nationally, and locally.[12,17,21,22,43] The report "Getting to Neutral: Options for Negative Carbon Emissions in California" includes natural and enhanced sequestration and storage in California's natural and working lands as a pillar of achieving net zero goals. That report suggests that California can achieve net zero emissions without out-of-state offset purchases, of which natural and working lands will contribute one fifth of the estimated negative emissions and storage.[12] The natural climate solutions for natural and working lands are to protect current natural and working lands from land use change to settlements or barren landscapes, to enhance lands' ability to sequester and store carbon through land management, and to restore degraded or lost natural and working lands to their natural states.[21,22,43]

Preventing land use change to less photosynthetically productive lands (i.e. settlements or barren landscapes) is consistently the least expensive natural climate solution and is highly effective.[21,22] While forest management and other land management techniques are effective tools in California and in the United States,[17,22,43] they are less important in Southern California, which is shrub dominated and has few forests that would benefit from forest management on a large enough scale (Figure 4.1).[17] Similarly, reforestation efforts are inappropriate in most of the San Diego region and are highly expensive.[17,22,43] Other restoration efforts are also expensive, though some efforts, like restoring riparian zones or savannas, are relatively less expensive and can contribute significantly to negative emissions in the San Diego region.[17,22,50] Riparian restoration will be considered in the agriculture and carbon farming section, while other restoration efforts will not be discussed extensively in this report. This section will focus on the negative emissions benefits of protecting existing carbon pools and carbon sequestration potential in natural and working lands through preventing land use change.

Land use change is a global problem that leads to net emissions as more productive carbon sequestering lands, like forests or grasslands, are turned into less productive lands, like settlements or high emissions agriculture.[14,20,24] The loss of natural and working lands that currently hold carbon and that sequester carbon annually is twofold: there is a one-time loss of carbon that is stored in soil and biomass and there is the lost sequestration potential of that land.[14] Net zero emissions scenarios rely heavily on preventing land use change that would result in net emissions (e.g., urban expansion, land conversion to croplands) and promoting land use change that would result in net sequestration (e.g., reforestation).[12,19,21,24]

Among the natural climate solutions listed above, preventing land use change is relatively inexpensive. National estimates for the U.S. suggest that over 60 MMT of CO_2e can be sequestered in 2025 for marginal abatement costs of $10 or less per MT of CO_2e simply through avoiding conversion of forest and grasslands.[22] Comparatively, reforestation, which has the highest potential for sequestering and storing carbon of any natural climate solutions that are considered at the global, national, or state level, is relatively expensive.[12,20,22,29] In the United States, this is largely due to the high costs of collecting seeds, raising seedlings in nurseries, and planting saplings in reforestable areas. When additional costs, such as maintenance and program evaluation, are considered, the costs increase further.[51] Additionally, costs vary by prevailing climatic conditions, infrastructure, workforce, and species, thus costs are likely to be higher in Southern California than in the Southeastern United States or Northern California, where conditions, infrastructure, and species are more amenable to reforestation.[12,51]

In the San Diego region, land use change occurs through natural processes, such as ecosystem succession after fires or pest invasions,[34,36,44] and through settlement expansion, such as urban and transportation expansion.[2,8,52] This section investigates the current approximate carbon storage and sequestration in the San Diego region using geospatially explicit vegetation data types from SANDAG's GIS portal (SanGIS.org).

Methods

All analyses, calculations, and data manipulation were done in QGIS 3.16 and Microsoft Excel. This analysis used SANDAG's "ECO_VEGETATION_CN" and "County_Boundary" shapefiles downloaded from SanGIS (SanGIS.org). Both shapefiles were downloaded in August, 2021. The former shapefile contains the vegetation community type for the entire region. The latter shapefile contains the San Diego County boundary. The layers were reprojected into California Albers (ESPG: 6414) and invalid geometries were fixed. The ECO_VEGETATION_CN layer was clipped using the County_Boundary to remove polygons that were in state waters or in other counties. The resulting layer's polygons show the San Diego region's land uses (Figure 4.1). The areas were calculated for each polygon and converted to hectares.

Carbon storage and sequestration values were taken from the literature (see Appendix 4.A.1 for sources). Whenever possible, local data were chosen. If local data were not available, then state, Pacific Coast, Western U.S., U.S., and global data were used, in that order. When there were multiple estimates in the same geographic area or when there was a range of possible values, the most conservative value was chosen. All carbon storage values were converted to metric tonnes of carbon dioxide equivalent or carbon per hectare (MT CO_2e or C ha^{-1}) and all carbon sequestration values were converted to metric tonnes of carbon dioxide equivalent per hectare per year (MT CO_2e ha^{-1} yr^{-1}) if the data were not already reported as such. Total carbon storage and sequestration values for the entire region were converted into millions of metric tonnes (MMT).

Carbon values were assigned to the Holland vegetation classes in the ECO_VEGETATION_CN dataset and were merged into the region's vegetation shapefile in QGIS. The polygon areas were multiplied by their corresponding carbon storage and sequestration values to return each polygon's carbon storage and sequestration totals. These data were exported to Excel and aggregated by broad land use type based largely on IPCC land use types. The IPCC's forest category was disaggregated to forests, woodlands, riparian, and shrublands; settlements were disaggregated to urban areas, disturbed areas, and agriculture; grasslands were consolidated to only include grasslands and meadows; and barren areas were disaggregated to water, barren (here meaning having no vegetation), and desert.

Results

The biodiverse and rich natural landscapes in the San Diego region have significant potential for both carbon storage and for annual carbon sequestration (Table 4.2). This analysis shows that there are approximately 58 MMT of carbon stored in San Diego's biomass and soils. Scrub ecosystems, including chaparral and coastal sage scrub, contribute most significantly to carbon storage, due in large part to their abundance and their local adaptations (Figure 4.1). Per hectare, coastal wetlands store the most carbon of any system. They are followed by tree-dominated systems, like woodlands, forests, and riparian areas. Wetlands are one of the least abundant systems in the region, though tree-dominated systems also have relatively low coverage. This is all readily visible in Figure 4.3, which shows the highest carbon storage per hectare values are red and the lowest as blue.

In addition to storage, the region also has high sequestration values and can sequester approximately 2.25 MMT of carbon per year. The largest sequestration potential is in scrublands, forests, woodlands, and riparian zones. However, settlements show some high sequestration potential because of urban trees (Table 4.2). Per polygon, forests and woodlands have the highest annual sequestration rates per hectare (Figure 4.4 – red values have the highest rates, blue have the lowest rates). Interestingly, disturbed wetlands have net positive emissions,[42,48,53] so those polygons (Figure 4.4 – black polygons) have negative sequestration values, despite continuing to store carbon (Figure 4.3).

Table 4.2 Total carbon storage (MMT CO_2e) and sequestration (MMT CO_2e yr^{-1}) in the San Diego region by land use category and for all land uses throughout the region.

Vegetation Category	Total carbon stock (MMT)	Total carbon sequestration (MMT)
Scrub	32.092964	1.4255247
Woodlands	12.718755	0.3457617
Forests	5.384545	0.3081349
Agriculture	2.34543	0.0242784
Riparian	1.7381	0.0747383
Grassland	1.431422	0.0007534
Settlement	1.2827819	0.0650613
Wetland	0.623143	0.0043672
Disturbed	0.235353	0.0001239
Desert	0.00477945	0
Water	0	0
Barren	0	0
Grand Total	**57.8572734**	**2.2487437**

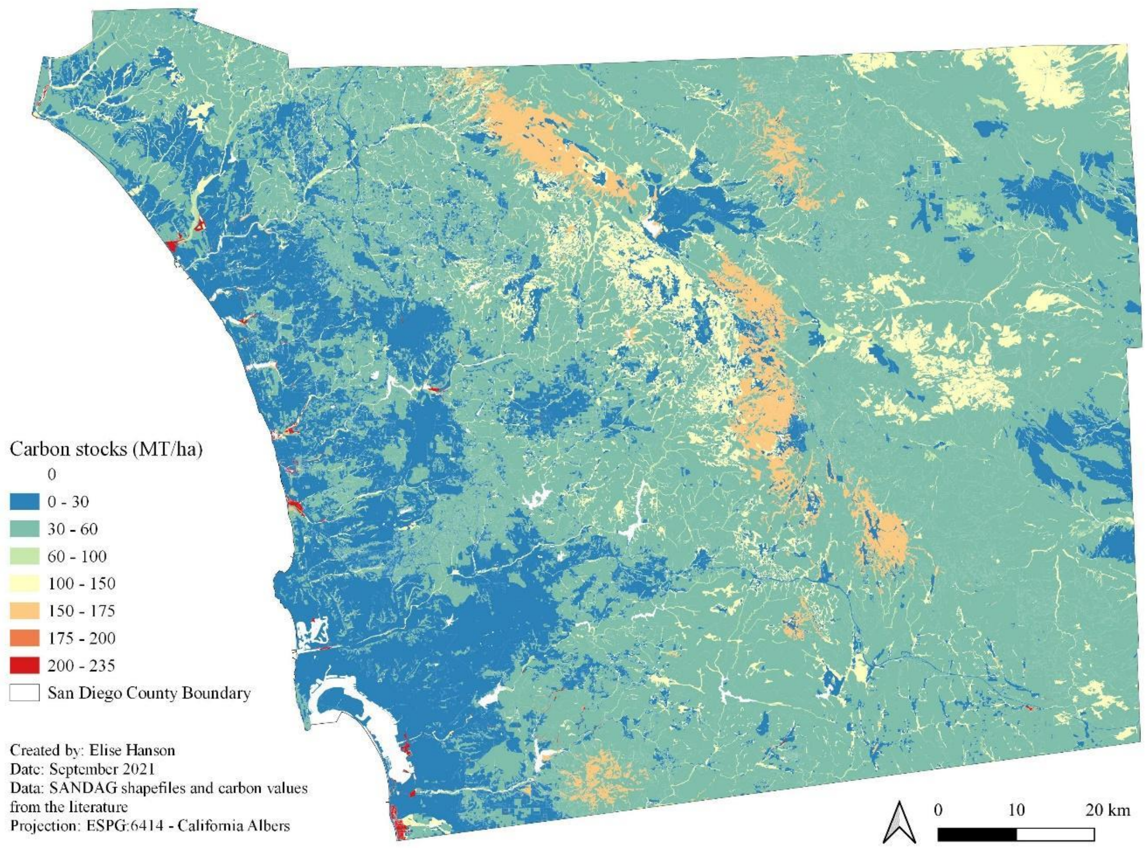


Figure 4.3 Total stored carbon (MT CO_2e ha^{-1}) estimates for the San Diego region. Warmer colors represent larger carbon stock estimates, cooler colors represent lower stock estimates, and white represents no carbon stock. Regionwide sequestration totals per vegetation category were calculated from these values and are in Table 4.2.

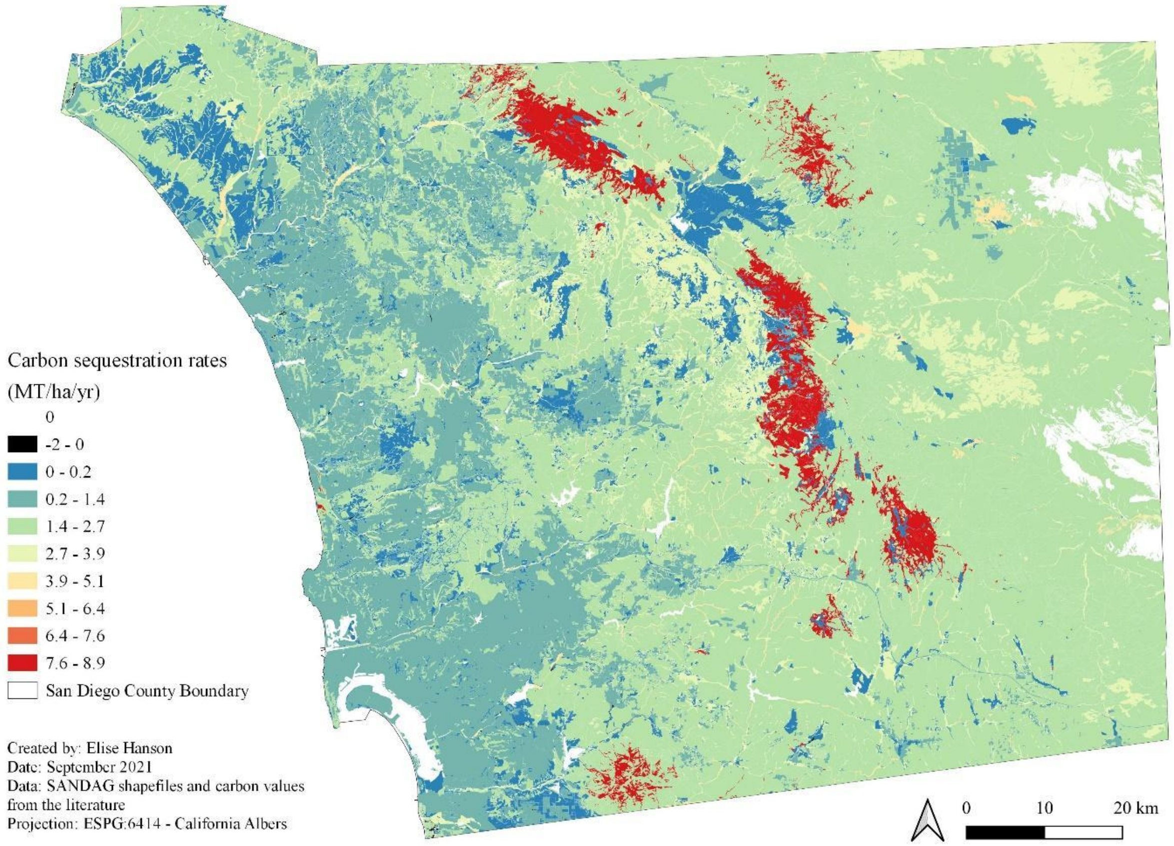


Figure 4.4 Annual sequestration rate (MT CO_2e ha^{-1} yr^{-1}) estimates for the San Diego region. Warmer colors represent higher rates, cooler colors represent lower rates, white represent no sequestration, and black represents net positive emissions. Regionwide sequestration totals per vegetation category were calculated from these values and are in Table 4.2.

Discussion

San Diego's natural and working lands represent two important natural climate solutions. First, the lands provide stable, long-term carbon storage for the region and keep carbon dioxide out of the atmosphere. Second, the lands provide annual net negative emissions by sequestering atmospheric carbon in plant tissues, thereby removing some of the region's anthropogenic emissions. This analysis is not comprehensive and is meant to illustrate that regional lands are currently producing natural climate solutions at little to no cost and that these lands should be valued for their sequestration and storage abilities.

This analysis broadly demonstrates that the region's natural and working lands are providing natural climate solutions at little to no cost. These carbon sinks are valuable for future decarbonization pathways because they store carbon and because they continually sequester carbon. Figure 4.3 shows that land use change throughout most of the region will result in large one-time emissions of carbon that is currently stored in biomass and soils. While positive emissions from land use change are not explicitly accounted for in any of the Climate Action Plans,[xii] this accounting is imperative to reaching a net zero future. Additionally, Figure 4.4 shows that land use change throughout most of the region will have long-term sequestration consequences, as those lands will sequester less carbon each year after they change. This accounting will also be imperative to consider as the lost annual negative emissions would need to come from other sources like other natural and working lands or technological solutions.[16,18] Development of natural and working lands is inevitable and will be important for other decarbonization pathways, especially for renewable energy siting (see Chapter 2 for more detail), but this analysis demonstrates that there are climate and emissions costs that would be incurred with land use change in the region.

There are some caveats and drawbacks to this analysis. First, local data were unavailable for some vegetation classes and the values used may not accurately reflect local conditions or circumstances. Local data will become more important in the future as droughts and phenomena affect the San Diego region. A study by Luo et al. (2007)[30] found that chaparral in San Diego is a strong sink in normal years, but becomes a source of CO2 in years of severe droughts. That study highlights the uncertainties in carbon accounting and the importance of localized data. Second, soil carbon estimates were not universally included in the literature or it was not clear whether soil carbon had been included in some stated values. Excluding soil carbon would underestimate the total stored carbon, but it is unlikely to affect the carbon sequestration rates because the majority of measured soil carbon is relatively shallow, where much of the long-term soil carbon storage is in deeper soil layers.[54] Third, eelgrass and other marine, beach, and intertidal plants and algae were not included in the vegetation classification shapefiles or were not included in enough detail to make determinations. Thus, their carbon storage and sequestration potentials are missing, despite the fact that they may be significant, which is almost certainly the case of eelgrass.[38,41,55] Fourth, this analysis was done at a coarser scale than other regional and localized analyses that are forthcoming.[xiii] Those more detailed analyses should be considered more accurate because they will better reflect plant biomass and soil carbon estimates as well as carbon sequestration potential. Finally, this analysis would benefit from research done by local institutions and organizations like WildCoast, the Climate Action Alliance, San Diego State University, and the Scripps Institution of Oceanography. When local data are available, they should be incorporated into all land use analyses as quickly as possible.

[xii] Personal communication Scott Anders, September 2021.

[xiii] Personal communication Drs. Megan Jennings and Matthew Costa, 2021 and information from the Climate Action Alliance detailed here: https://www.climatesciencealliance.org/carbon-sequestration

Policy implications

This analysis illustrates that an ounce of prevention is worth a pound of cure – protecting a hectare of natural and working lands will prevent emissions and will continue to sequester carbon in a low to no cost manner. As such, natural and working lands contribute to negative emissions in the region and mitigate some local anthropogenic emissions. Meanwhile, losing natural and working lands would require expensive restoration, mitigation, or negative emissions technology investments to capture the one-time emissions of stored carbon and to continue to sequester the carbon that those lands would have sequestered naturally.

Further, this analysis illustrates that those efforts to characterize the carbon storage and sequestration capacity of natural and working lands in the San Diego region should be supported by governments because current policies are generally not informed by the most localized carbon cycling data. Similarly, this analysis shows that preventing or mitigating emissions from land use change is crucial. Thus, regional governments should include emissions from lost biomass and soils as well as the lost carbon sequestration potential when deciding land use policies and decarbonization pathways. Additional effort should be applied to monetizing these emissions and lost sequestration potential in order to properly incentivize natural and working land protection and to understand the extent of regional net negative emissions.

Policy recommendations:

- Prevent land use change from natural and working lands to settlements or other less productive lands when possible.
- Support SANDAG's urban growth plans that promote densification.
- Support studies to accurately measure and report local carbon stocks and sequestration rates.
- Consider incorporating the costs of carbon dioxide emissions from land use change and the lost carbon dioxide sequestration potential into land use planning decisions.

4.4 Agricultural sector

Introduction

Agriculture is usually a net GHG emitter because livestock, farmed animals, and rice fields release methane; soil bacteria release nitrous oxide; and crop production and harvesting release soil carbon (Figure 4.2).[14,15,24] Many natural climate solutions focus on ways to both reduce carbon dioxide emissions and enhance sequestration potential,[21,22,24] where methane and nitrous oxide management are more nuanced and difficult[26,27] However, manure and fertilizer management can reduce methane and nitrous oxide emissions, respectively.[21,50]

This report will focus on the carbon dioxide implications of agricultural climate solutions, sometimes referred to as “climate farming,” though it will note important considerations for methane and nitrous oxide when applicable. The two primary methods for addressing CO_2 sequestration and emissions in existing agriculture are to amend soils or otherwise change farming practices to increase the stored carbon in the soil and to prevent emissions. Examples of the former include adding on-farm compost to soils, planting cover crops, planting trees in or around farms or pastures, planting perennial plants rather than annuals, or adding biochar. Examples of the latter include cover cropping, practicing no or low-till agriculture, planting perennial plants rather than annuals, or planting trees.[12,20,21,50]

It is important to state that there are significant uncertainties in GHG accounting in agricultural lands because the soil gas interchanges are complicated and highly heterogeneous (they depend largely on weather and inputs on any given day and on existing soil gas composition).[12,27] The majority of agricultural climate discussions that focus on the United States rely on the Department of Agriculture’s (USDA) COMET planner[xiv] and the discussions that focus on California use a California-specific COMET planner tool[xv], with additional help from the California Air Resources Board and the California Department of Food and Agriculture. This tool is important, though it should be used carefully because there are some important caveats to these data. First, the data behind the estimates represent 10-year averages and the values should be considered invalid beyond that timeframe.[12,56] Second, the models that use the field data are simple relative to the biochemical interactions in soils. Given that soils are highly dynamic systems, there are concerns that the COMET planner overestimates the amount of carbon that will be stored and may simultaneously underestimate the potential nitrous oxide emissions.[12,27] Further, the report “Getting to Neutral” notes that the models underlying the COMET planner also likely overestimate how much carbon is stored in deeper, and thus longer term, soil storage.[12] Thus, the “Getting to Neutral” report, and others, emphasize the importance of longer term monitoring of local demonstration farms where climate farming practices have been implemented.[12,50]

Discussion

In lieu of sufficient localized carbon sequestration data, Dr. Puja Batra produced a report[50] for the unincorporated San Diego region to recommend policies for the County regarding climate farming and transforming agricultural lands from sources to sinks using California-specific COMET planner data. That report focused on compost applications in orchards, rangelands, and

[xiv] http://comet-planner.com/

[xv] http://www.comet-planner-cdfahsp.com/

row crop fields as well as riparian restoration, though it also discussed preventing the removal of orchard trees due to increasing marginal costs of watering and losses due to fire.

Compost application yielded the highest carbon sequestration benefits, according to Batra,[50] resulting in 227,170 MT of CO_2e sequestered annually. However, the report notes that there are potential problems of nitrogen leaching into surface water and groundwater if the application rate is too high or if the nitrogen levels in the compost are too high.[50] Repeated application of compost may result in eutrophication[50] and/or net GHG emissions from the soil,[12,27,43] so compost application for the sake of carbon sequestration will need to be coupled with monitoring. Regardless of carbon sequestration potential, compost application may offer co-benefits in reduced application of synthetic fertilizers, which could reduce NO_x emissions;[22] improved manure management, which could reduce CH_4 and NO_x emissions;[12,22,50] and increased soil water retention.[20,22,50]

Batra[50] also investigated riparian restoration as a means of sequestering carbon in the region's agricultural lands. The unincorporated county has nearly 7,000 miles of freshwater and riparian systems,[50] which are typically dominated by shrubs and trees and have higher carbon sequestration potential than forb and grass-dominated systems.[2,6,24] Restoring riparian ecosystems typically involves planting native trees and shrubs, which is estimated to result in approximately 2 MT of CO_2e sequestration per acre per year.[50,56] Batra estimated restoration of about 25% of riparian habitats and 35 feet of buffer zones around them would result in approximately 7,230 $MTCO_2e$ per year.[50] Together, compost application and riparian restoration may sequester up to 234,400 $MTCO_2e$ per year.[50]

Finally, Batra considered the emissions from recent orchard tree removals and the lost sequestration value of those trees. The unincorporated county lost approximately one million orchard trees from 2000 to 2015. Many of the trees were removed because rising marginal costs of inputs like water forced farmers to save costs by removing some of their orchard trees.[50] Trees are particularly good at sequestering carbon because they deposit carbon deep in the soil and store carbon in biomass,[12,20,21,29] so removing these orchard trees has two carbon related impacts. First, it releases stored soil carbon and begins the process of releasing the biomass carbon. Second, it reduces the orchard's annual sequestration potential because the removed tree is no longer able to sequester carbon annually.[50] Batra estimated that the lost orchard trees released 243,468 MT of CO_2e and lost the ability to store 131,657 MT of CO_2e during that period. All told, the loss of orchard trees in the unincorporated county is estimated to be more than 375,000 MT CO_2e.[50] This analysis highlights the importance of retaining existing carbon pools, however, it also speaks to the incentives that farmers face.

Beyond Batra's report, other carbon farming methods to consider should include cover cropping, improved species selection, and restoration of degraded, abandoned, or marginal agricultural lands.[12,20–22] Importantly, each of these techniques has co-benefits, including increased soil water retention, increased biodiversity, more shade for livestock, improved or increased habitat, and/or increased agricultural yields.[20–22,57] The restoration component is likely to offer the greatest co-benefits for the San Diego region in large part because planting trees in grasslands leads to large belowground and aboveground carbon storage gains as well as improved biodiversity, soil health, water quality and quantity, and air quality outcomes.[12,20–22,24] Given that the region's agricultural output and acreage are dominated by livestock grazing, rangelands, and pasturelands,[2,58] planting trees in grasslands is likely to improve regional carbon sequestration while offering numerous co-benefits.

Addressing methane and nitrous oxide emissions is generally more difficult because there are generally fewer carbon farming solutions, despite the fact that they contribute more warming potential to the atmosphere than CO_2.[13,14,21,24,50] Methane in the San Diego region is primarily emitted from landfills, livestock manure, enteric fermentation, and wastewater, though there are also some methane emissions from natural decomposition in wetlands and wetland loss.[12,17,20,24,47] Batra did not account for the agricultural methane that is prevented from entering landfills because avoided methane emissions are covered by regional climate action plans and would constitute double counting.[50,59,60] This would also be the case for the City of San Diego's wastewater emissions.[59,60] There are, however, some manure and enteric fermentation management techniques that would not be double counting for the region. These include on-site anaerobic manure digestion, methane capture or digestion from enteric fermentation, methane reduction from enteric fermentation.[12,50,57,61,62] The opportunities to reduce methane and nitrous oxide emissions in the region's agriculture sector require further study, but they may provide important GHG emissions reductions.

Two demonstration projects hosted by the Resource Conservation District of Greater San Diego County[58,63] and several independent agricultural operations in San Diego County[64] offer examples of carbon farming and monitoring and will provide further insight into the carbon sequestration benefits and the capital costs associated with the new techniques, processes, and monitoring. Projects like these will be critical for understanding the long-term costs and benefits of carbon farming and may help to create a local market for carbon offsets.[64]

Policy implications

Localized data from farms, orchards, pastures, and rangelands will be crucial to understanding the carbon storage benefits of different carbon farming techniques. There are significant uncertainties associated with the USDA and CDFA's data that underlie the COMET planner tools,[12,56] largely because soil systems are complex and nuanced and because soil carbon storage is highly dependent on local conditions.[12,27,29] Thus, improved data for local agricultural productions would enhance the region's understanding of agricultural carbon fluxes and would better inform carbon farming techniques and policies.

Additionally, cost data should be collected and incorporated into carbon farming analyses. Many carbon farming techniques are expensive because they require additional or specialized machinery. For example, no-till agriculture prevents soil carbon losses during tilling, but requires using specialized machinery for seeding. Conversely, compost application requires a much smaller investment into a tractor attachment.[50] Further, data collection can be costly and there is little economic incentive for farmers to independently engage in regular soil testing to track carbon storage.[64] Thus, the costs of new equipment investments, marginal operating and management of carbon farming, and soil testing should be incorporated into cost-effectiveness and/or cost-benefit analyses to inform government spending on subsidizing or otherwise reducing the costs of carbon farming.

Finally, stakeholder input generally agreed that the incentive structures are not set up to incentivize carbon farming in the region. There seems to be high agreement that local farmers need financial assistance in order to address their carbon emissions and to allow them to engage in carbon farming. Policies addressing carbon farming will need to focus on incorporating farmers' experiences, concerns, and cost data in order to maximize carbon storage potential in an equitable manner.

Policy recommendations:

- Study local carbon farming techniques to better understand carbon storage and sequestration potential, costs, associated ecosystem services, and economic benefits.
- Consider subsidizing tree planting in and around agricultural lands and additionally incentivizing farmers to retain existing trees.
- Engage farmers and other stakeholders to create carbon farming policies that are equitable, just, and beneficial to farmers and farming communities.

4.5 Blue Carbon and Sea level rise

Introduction

Blue carbon generally refers to the carbon storage and sequestration potential in vegetated coastal ecosystems, like seagrass beds, marshes, wetlands, and mangrove forests, but it sometimes specifically refers to restoring vegetated coastal ecosystem in order to improve carbon sequestration and storage.[20,39] Coastal ecosystems are known for their many ecosystem services, including many economically valuable services such as storm surge reduction, wave action and wind buffering, commercially important fish nursery habitats, and air and water quality improvements.[20,57] Further, many coastal ecosystems are being protected because they collectively store disproportionately high levels of carbon per unit area than the majority of ecosystems and store carbon on the order of millennia.[38,41,65]

The San Diego region historically contained over half of the Southern Californian Bight's blue carbon habitats (~11,000 hectares), much of which was in the Mission and San Diego Bays. Since mapping efforts began around 1850, it is estimated that San Diego has lost approximately 31% of its historic wetlands through conversion to non-wetland systems like urban development.[66] Wetlands throughout the region are susceptible to land use change, sea level rise, and invasive species, all of which would reduce or eliminate annual carbon sequestration and emit carbon dioxide and methane that are stored in the soils.[17,20,47,48] As with terrestrial carbon storage and sequestration, the primary methods of maintaining or enhancing blue carbon are through protection of existing wetland ecosystems and restoration of degraded or lost wetland ecosystems.

The San Diego region has lost seagrass beds, salt marshes, mudflats, coastal riparian zones, and other intertidal zones[39,48,66] and will likely continue to lose these habitats into the future.[42,46,53] Of these lost ecosystems, only some will be eligible for restoration,[17,48] which highlights the importance of protecting existing ecosystems. Additionally, there are strong economic reasons to prevent further wetland loss or degradation. First, wetland restoration results in less annual sequestration than comparable non-forest restoration, all while costing more.[12,67] Protecting existing wetlands will be less expensive and more effective than restoring or mitigating wetland loss. Second, the one-time releases of stored carbon dioxide and methane will be significant because wetlands have a higher density of carbon storage per unit area than other regional ecosystems,[38,39,41] so the costs of offsetting or removing those emissions from even geographically small lost wetlands will be significant. Third, an estimate by The Nature Conservancy of California found that wetland restoration in California would result in over $1 billion of avoided climate-related damages due to ecosystem services provided by expanded wetlands,[17] highlighting the importance of existing wetlands, which currently provide those services at no cost. Fourth, wetland restoration is expensive, so it is economically important for the region to prevent wetland loss and apply restoration funds to natural climate solutions that have lower marginal costs and higher sequestration rates.[12,21,22]

While wetlands contribute meaningfully to negative emissions, they are predicted to emit more CO_2 than they sequester with sea level rise, absent wetland migration, or land use change to wetlands as sea water inundation occurs.[42,47,48] This analysis shows the potential carbon dioxide emissions from lost wetland habitats in the San Diego region under 1 foot of sea level rise, which is expected to occur by approximately 2030.[45] The analysis then estimates the land use requirements of direct air capture (DAC) that would be needed to sequester the released CO_2 as a demonstration of some of the costs required to offset wetland loss.

Methods

The City of San Diego published a draft report showing that they predict local sea level rise (SLR) of approximately 0.25 meters, or about 1 foot, by 2030.[45] The report found that 0.25 meters of SLR would inundate about 43% of the City's remaining salt marshes.[45] To analyze the lost blue carbon potential and the emissions from lost wetland habitats, the National Oceanic and Atmospheric Agency's Orange and San Diego county sea level rise data were used.[68] The 1 foot of SLR layer was reprojected into California Albers (ESPG: 6414) and invalid geometries were fixed. The current, fixed vegetation layer from SANDAG, in ESPG: 6414, from the land use section was used to show the vegetation types that would be affected by 1 foot of SLR.

The vegetation layer was filtered to only include the categories of bogs, marshes, riparian, and bottomland habitats. These remaining vegetation types were further filtered to remove habitats that are not typically considered blue carbon such that only marshes, estuaries, riparian areas, and mudflats/saltpans remained (see Appendix 4.A.2 for details). Seagrass was excluded from this analysis because it is not included in vegetation mapping. Further study into seagrass contributions to blue carbon accounting and the effects of sea level rise on that carbon sink would be beneficial because seagrass is an important blue carbon ecosystem.[40,41] The final areas of each polygon were calculated in units of hectares and final polygons with an area equal to zero hectares were dropped, as in the land use change section.

The blue carbon vegetation class was used to determine the emitted carbon from the carbon stock and the lost carbon sequestration potential. These values were taken from the literature and were preferentially from San Diego, California, the west coast of the contiguous United States, anywhere in the United States, or any blue carbon study, in that order. A table of values and sources is in Appendix 4.A.2. The carbon stock and sequestration values from the literature were converted to metric tons of carbon dioxide equivalent per hectare (MT CO_2e ha^{-1}) if they were not already in those values. They were then multiplied by the appropriate vegetation class's total area to get the one-time positive emissions and the foregone negative emissions from planned land use change in the region.

Results

The anticipated 1 foot of sea level rise by 2030 is projected to result in a loss of nearly 800 hectares of blue carbon habitats throughout the region, an area approximately 1.4 times the size of downtown San Diego (Table 4.3, Figure 4.5).[69] This level of loss will result in approximately 180,112 MT CO_2e emitted directly into the atmosphere. Additionally, the lost habitats would have been able to sequester approximately 1,715 MT CO_2e per year (Table 4.3). In order to offset these one-time emissions and to sequester the carbon dioxide that would have been sequestered, a comparable level of new wetlands, marshes, and riparian habitats would need to be restored prior to 2030. However, such restoration efforts would merely allow the region to break even by sequestering as much as is being emitted from blue carbon habitats.

Table 4.3. Total lost habitat (hectares), annual carbon sequestration (metric tonnes per year), and long-term storage (metric tonnes emitted upon loss) per blue carbon vegetation class.

Vegetation classification	Total area lost with 1 foot of SLR (ha)	Lost annual sequestration (MT CO_2e yr^{-1})	Lost carbon storage (MT CO_2e)
Freshwater marsh	20	28	3,020
Mudflats/Saltpans	22	44	5,082
Riparian scrub	14	60.2	1,400
Salt marsh/estuary	726	1,582.68	170,610
Total terrestrial blue carbon ecosystems	**782**	**1,714.88**	**180,112**

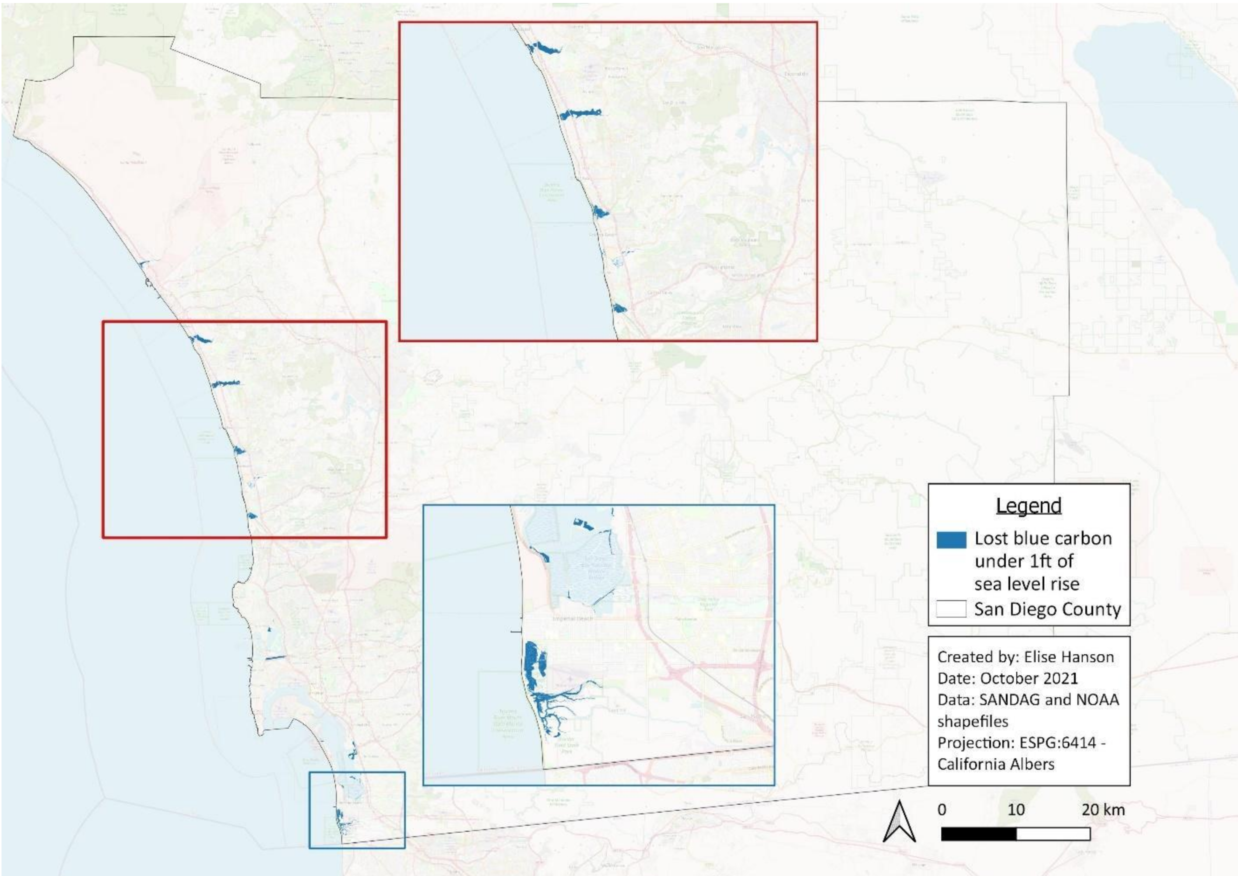


Figure 4.5. Some blue carbon habitats will be lost under 1 foot of sea level rise in the San Diego region. Blue areas in the map show such habitats, which are quantified by ecosystem category in Table 4.3. Insets show more detail of two regions with blue carbon losses.

Discussion

As in the case of regional land use change in forests and non-forest terrestrial ecosystems, protecting wetlands, marshes, mudflats, and riparian habitats from loss is the first-best option because doing so both protects existing stored carbon stocks and ensures annual carbon capture and sequestration. Protection of existing blue carbon habitats is especially important because they hold larger quantities of carbon per unit area and for longer periods of time than San Diego's forest and non-forest ecosystems.[38,53,55,67]

Unlike regional land use change, which can generally be planned for and can thereby be reasonably prevented, blue carbon ecosystem loss is inevitable given current estimations of sea level rise and the dearth of options to prevent sea water inundation and flooding.[20,42,46] Similarly, restoration of other ecosystems in order to offset the anticipated losses of blue carbon ecosystems will be expensive and likely impractical, given the challenges of restoration.[12,17,51] Thus, the remaining options are to expand existing blue carbon habitats, and thus allow for so-called wetland migration, or to invest in other natural climate solutions in the region.

Policy implications

Wetland, marsh, and mudflat losses will significantly impact the ability of the region's natural climate solutions to contribute to negative emissions. Local carbon sequestration and storage data are forthcoming from organizations like the Scripps Institution of Oceanography (pers. comm., Dr. Matthew Costa, July 22, 2021), which will improve the analysis of anticipated impacts from sea level rise. Nevertheless, the unique threats of sea level rise and the eventual emissions from low-lying blue carbon ecosystems should be accounted for in decarbonization plans, even if data are imperfect.

Policy recommendations:

- Protect existing carbon storage pools in blue carbon ecosystems from anthropogenic land use change.
- Collaborate with organizations and governments to study local blue carbon values to improve blue carbon accounting in the region.
- Collaborate with organizations and governments to study the feasibility and costs of wetland migration, wetland restoration, and carbon sequestration enhancement in existing wetlands.

4.6 Urban trees

Introduction

Urban trees are those trees which exist within urban boundaries and were either planted or are somehow maintained.[70–72] Trees are often planted in urban settings because they provide ecosystem services like reducing air pollution, providing shade that cools buildings, reducing urban stormwater runoff, increasing aesthetic value, reducing noise, and other services.[17,70,71] However, urban trees are also being recognized for their contributions to negative carbon dioxide emissions because their growth reduces atmospheric CO_2.[17,73,74] Urban trees provide the only natural climate solutions for urban areas and settlements that have replaced natural and working lands, so it is critical for such areas to have urban trees to produce negative emissions in lieu of natural landscapes. Further, these trees also provide co-benefits that were lost to land use change to surrounding communities that are disproportionately affected by poor air quality, high temperatures, and little shade or green space.[17,70]

There are, however, some important caveats to urban forestry that are worth consideration in the San Diego region and elsewhere. First, urban trees are more stressed than their wild counterparts and thus have shorter lifespans on average, though they can still sequester carbon for more than 40 years.[75] The shorter lived urban trees will require more frequent replacement than naturally occurring trees in natural landscapes, which will need to be factored into planning. Second, if urban trees require large inputs, like water and fertilizers, that in turn require fossil-fuel based inputs, like energy or synthetic fertilizers, then urban forests can be net emitters because their care can require more CO_2 emissions than they can sequester.[75] Third, the species of tree planted has large implications for carbon sequestration, life expectancy, water and maintenance needs, and potential co-benefits, highlighting the importance of careful tree selection based on local conditions and needs.[75–77] Fifth, as trees reach the end of their lives, they will need to be replaced in order for the urban forest to continue to provide services. Thus, tree planting goals may be too low as urban forests age and die.[78] Finally, urban greening often focuses on trees because of their ability to provide unique services like shading and subsequent cooling, but regional greening should also include plans to plant native or non-native drought tolerant shrubs and plants. These plants can offer aesthetic value, air pollution mitigation, water quality improvements, improved habitat and biodiversity, and carbon storage all while generally requiring fewer inputs than trees.[17,70,79]

Discussion

In a 2003 San Diego regional analysis, the non-profit American Forests produced a report of the tree cover in the City of San Diego and 22 surrounding cities and communities and found that, collectively, these urban forests stored 640,846 MT of carbon and sequestered 4,864 MT of carbon annually.[70] Despite the significant sequestration and storage values, the study region lost 29% of its tree cover from 1985 to 2002.[70] While California as a whole has steadily gained tree cover and urban carbon sequestration since 1990,[73,80] the San Diego region has not seen similar gains and thus has the potential to create substantial negative emissions through expanding urban tree cover.[17,70,78]

A 2021 national report by American Forests projected carbon storage and sequestration based on stated tree planting goals in different jurisdictions and assuming a 1% dieback rate of existing trees using current carbon storage and sequestration values, recognizing that there will be climate-related feedbacks to tree growth and life expectancy in response to localized climate change.[78] The report found that San Diego County is expected to increase its urban tree carbon storage by approximately 6 MMT of carbon and to increase its annual sequestration rate by 0.32 MMT of carbon per year from 2010-2060 through urban tree expansion alone.[78] The report also noted that San Diego County is expected to see an increase in avoided emissions as urban trees are expected to reduce electricity use for cooling, though, importantly, there will be increased emissions with urban expansion and overall avoided emissions will be reduced through the loss of natural lands.[78]

An analysis by The Nature Conservancy of California found that the San Diego region had 111,763 acres of urban land that was suitable for urban forestry or other greening.[17,81] At an average sequestration rate of approximately 7 MT of CO_2e per acre per year, the report estimates that fully foresting the San Diego region's urban areas would result in over 2 MMT CO_2e of annual sequestration.[17,81]

Though these estimates are rough because they are not based on extensive field data, they still highlight the importance of greening the region's urban areas as a natural climate solution. As cities and municipalities throughout the region set and achieve tree planting goals, it will be important to account for accurate, localized carbon stock and sequestration values based on species, tree age, tree health, and growing conditions. Additionally, it will be important for urban areas to account for both the electricity savings due to trees' cooling effects and to account for the emissions from inputs like watering, tree care, fertilizers, etc.

Policy Implications

Urban forestry is an important natural climate solution for urban and developed areas because they can sequester and store carbon in an environment that is otherwise unable to provide negative emissions and can replace some of the natural sequestration and storage that was lost.[70] Their numerous co-benefits and their ability to increase equity and improve social welfare through air and water quality improvements, cooling effects, aesthetic improvements, and more are also important reasons to increase urban canopy cover and urban tree distribution.[79,82] However, as a natural climate solution, urban trees pale in comparison to natural systems, so the first best choice is always to protect and enhance natural systems, which are more efficient systems for generating negative emissions, rather than expand urban areas and create an urban forest.[12,17,21,29,78]

Nevertheless, there are ways to increase urban tree carbon sequestration and storage potential and maximize their value to negative emissions. First, governments can choose tree species and adjust tree management practices to maximize carbon benefits. Ideally, species would be low-water, long-lived, low-maintenance, and large trees that are well-suited for the local climate.[75] This simple step could increase the lifetime of the tree, increase the lifetime of carbon storage, and reduce lifetime, carbon-intensive inputs like water. Second, governments can plan or encourage private landowners to plan tree locations to maximize cooling effects on structures or surfaces.[75] It is important to note that these locations need to be carefully balanced with providing defendable space for those areas which are prone to fires or otherwise have increased fire risks. Third, governments can empower and encourage local communities to collect data on trees in their areas to inexpensively improve overall urban tree data.[70] These data can inform distribution, size, and species urban forest information that can aid decision makers in crafting urban forestry policies that will increase carbon storage and sequestration while providing local co-benefits equitably.

Policy recommendations:

- Plant trees that maximize lifetime net negative emissions and net carbon storage.
- Plan tree planting locations in public spaces to maximize co-benefits like shade and provide information and education to private landowners to assist in tree planting location choices on private land.
- Actively (government led) and/or passively (community led) collect data on urban forests to improve policy and decision making.

4.7 Regional Natural Climate Solutions Policy Recommendations and Conclusions

As the County of San Diego and other governments in the San Diego region plan for decarbonization in order to meet net zero emission goals, natural climate solutions will be an important part of the decarbonization pathway. Natural climate solutions and natural and working lands contribute to decarbonization through sequestering atmospheric carbon annually and through storing atmospheric CO_2 in plant tissues for the medium to long-term. However, natural and working lands can also contribute to regional emissions when they are lost due to development, natural disasters like wildfires, or climate change induced ecosystem changes like sea level rise. General policy recommendations for carbon sequestration and storage through natural climate solutions follow.

Sequestration

The simplest, cheapest, most effective regional policy to contribute to natural climate solutions is to prevent land use change and allow natural and working lands to continue to sequester carbon naturally. The San Diego region has a large quantity of conserved lands and has plans to conserve more lands,[52] so continuing to protect conserved lands and expanding protections to additional lands will provide annual carbon sequestration and low to no cost negative emissions of more than 2 million tons of CO_2e stored annually. Other natural climate solutions like reforestation, forest management, or other restoration techniques, are typically highly effective at removing CO_2, but they are almost universally more expensive than merely protecting existing lands.[21,22] The County, as well as other governments and agencies in the region like tribal governments and federal agencies, can contribute to regional net negative emissions through preventing land use change among their natural and working lands. In addition to continuing conservation and preservation efforts, governments can research or partner with research groups to better characterize the carbon sequestration potential in the region’s natural and working lands. Doing so will allow for better carbon accounting and reduced uncertainties and will also help inform better management policies and practices to maximize natural climate solutions.

Next, regional governments can research and incentivize carbon farming techniques like compost application, riparian restoration, and orchard tree retention. Additional research should investigate how rangeland tree planting, no-till agriculture, crop choice, manure management, and grazing/livestock feed management affect agricultural emissions. Carbon farming is widely considered to be the best way to transform the agricultural sector from a carbon source to a carbon sink and will likely be important for the San Diego region's decarbonization efforts.[12,22,43,50]

Wetlands, marshes, and other blue carbon ecosystems contribute less to annual sequestration than tree and shrub-dominated ecosystems, but they nevertheless play an important role in total carbon sequestration. Protecting these systems from land use change and restoring them will contribute to continuing sequestration in the near-term. Restoration of surrounding habitats may allow blue carbon habitats to migrate as sea level rise inundates coastal areas, thereby allowing blue carbon systems to continue to sequester carbon in the medium and long-term.

Last, local governments should continue to increase urban tree canopy cover because these trees make urban and other settlement areas carbon sinks (Table 4.2). Additionally, governments can study tree species and location selections to maximize carbon sequestration rates, minimize inputs like water, and maximize co-benefits. The latter will be especially important as governments pursue environmental justice policies that aim to provide public goods to disadvantaged and low-income communities.

There are additional natural climate solutions to increase sequestration rates that were not investigated here but which are important to consider and study. For example, while forest management is not widely applicable in the region, non-forest management of chaparral and scrub ecosystems may improve regional sequestration rates and should be investigated for effectiveness and cost.

Storage

As with carbon sequestration, the simplest and cheapest way to maintain the naturally stored carbon is to protect natural and working lands from land use change. By protecting existing carbon storage, the region can prevent large one-time emissions from land use change. Beyond protecting lands from deliberate land use change, governments can research carbon storage values in the region to characterize the magnitude of stored carbon. Such efforts would elucidate the role of natural and working lands in helping the region understand long-term land use carbon accounting under different development strategies.

Similarly, blue carbon ecosystems are particularly adept at storing large quantities of carbon and are therefore disproportionately vulnerable to large emissions if they are lost. Wetlands, marshes, and other coastal systems should be actively protected from land use change to settlements and should be restored and enhanced when possible in order to increase coastal carbon storage and to prepare for loss due to sea level rise. Researching blue carbon ecosystems would provide similar relevant information as researching other land uses in the region and would similarly inform emissions under different development and restoration strategies.

Agricultural lands hold carbon primarily in trees, like orchard trees, and in soils. Some carbon farming techniques, like composting and riparian restoration, are likely to increase stored carbon in agricultural lands. These techniques, and other carbon farming techniques, will have variable effects by locality, and should thus be researched and characterized. Regardless of carbon farming, agricultural lands store more carbon than barren landscapes or settlements that do not have urban trees. As such, preventing land use change can also be an important measure in active, productive agricultural lands.

Urban trees and vegetation lead to the only carbon storage that occurs in settlements and urban areas. These trees, shrubs, and other green spaces are not as efficient at storing carbon as the native ecosystems that were historically present, however, they still provide medium-term carbon storage and should be protected and expanded. As urban trees die, they should be replaced with appropriate species to maximize total carbon storage as well as carbon storage longevity while also minimizing lifetime inputs, like water.

Finally, some natural climate solutions that can protect or enhance carbon storage were not included here but are still important to consider. For instance, wildfire prevention via educational programs and infrastructure hardening will reduce wildfire emissions and will allow natural systems to regenerate after wildfires and recover the emitted carbon as plants regrow.[34]

Uncertainty and future research

This report's analyses have some important uncertainties. These primarily come from the fact that localized carbon storage and sequestration data are largely unavailable. This is problematic because local climate, prevailing fire regimes, ecosystem composition, and environmental stressors like drought have significant impacts on any given local natural climate solution effectiveness. Regional governments should utilize the most recent and localized data possible when estimating natural climate solutions' contributions to decarbonization. Data on local chaparral and blue carbon storage and sequestration are forthcoming.[xvi] These data will be critical to understanding valuing regional land contributions to negative emissions and long-term carbon storage.

Additionally, regional governments should quantify the full breadth of co-benefits and ecosystem services provided by natural and working lands, carbon farming, blue carbon, and urban forestry. In particular, water savings, ground water recharging, air and water quality improvements, equity improvements, property damage reductions from storm surges and other natural phenomenon, biodiversity protection, climate and other refugia protection, and wildfire prevention should be considered, quantified, and maximized in addition to carbon sequestration and storage.

[xvi] Personal communication with Zachary Plopper, Dr. Meagan Jennings, and Dr. Matthew Costa, 2021.

Works Cited

1. Marchese, C. Biodiversity hotspots: A shortcut for a more complicated concept. *Glob. Ecol. Conserv.* **3**, 297–309 (2015).
2. Pairis, A. D. *et al. Chapter 1: Introduction to San Diego's Climate and Ecosystems*. 1–11 (2018).
3. The Nature Conservancy. San Diego County. *The Nature Conservancy* https://www.nature.org/en-us/get-involved/how-to-help/places-we-protect/san-diego-county/ (2021).
4. Cowling, R. M., Rundel, P. W., Lamont, B. B., Kalin Arroyo, M. & Arianoutsou, M. Plant diversity in mediterranean-climate regions. *Trends Ecol. Evol.* **11**, 362–366 (1996).
5. Hung, K.-L. J., Sandoval, S. S., Ascher, J. S. & Holway, D. A. Joint Impacts of Drought and Habitat Fragmentation on Native Bee Assemblages in a California Biodiversity Hotspot. *Insects* **12**, 135 (2021).
6. Rebman, J. P. & Simpson, M. G. *Checklist of the vascular plants of San Diego County*. (San Diego Natural History Museum, 2014).
7. Wisinski, C. Conservation: It's Closer Than You Think. *Saving Species - Institute for Conservation Research, San Diego Zoo Global* vol. 1 (2018).
8. Soule, M. E., Alberts, A. C. & Bolger, D. T. The Effects of Habitat Fragmentation on Chaparral Plants and Vertebrates. 10 (1992).
9. California Department of Fish and Wildlife. BIOS Viewer, Version 5.96.99. https://apps.wildlife.ca.gov/bios/?tool=cnddbQuick (2021).
10. Rojas, I. M. *et al.* A landscape-scale framework to identify refugia from multiple stressors. *Conserv. Biol.* cobi.13834 (2021) doi:10.1111/cobi.13834.
11. Underwood, E. C. *et al.* The impacts of climate change on ecosystem services in southern California. *Ecosyst. Serv.* **39**, 101008 (2019).
12. Baker, S. E. *et al. Getting to Neutral: Options for Negative Carbon Emissions in California*. https://www.osti.gov/biblio/1597217 (2019) doi:10.2172/1597217.
13. Potter, C. The carbon budget of California. *Environ. Sci. Policy* **13**, 373–383 (2010).
14. Friedlingstein, P. *et al.* Global Carbon Budget 2020. *Earth Syst. Sci. Data* **12**, 3269–3340 (2020).
15. U.S. Environmental Protection Agency. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2019*. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks (2021).
16. Goldstein, A. *et al.* Protecting irrecoverable carbon in Earth's ecosystems. *Nat. Clim. Change* **10**, 287–295 (2020).
17. Chamberlin, S. J. *et al. Nature-based Climate Solutions*. 113 (2020).
18. Roe, S. *et al.* Contribution of the land sector to a 1.5 °C world. *Nat. Clim. Change* **9**, 817–828 (2019).
19. International Energy Agency. Net Zero by 2050 - A Roadmap for the Global Energy Sector. 224 (2021).
20. Canadell, J. G. *et al. Global Carbon and other Biogeochemical Cycles and Feedbacks*. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter_05.pdf (2021).
21. Griscom, B. W. *et al.* Natural climate solutions. *Proc. Natl. Acad. Sci.* **114**, 11645–11650 (2017).
22. Fargione, J. *et al.* Natural climate solutions for the United States. *Sci. Adv.* **4**, eaat1869 (2018).
23. Hanson, R. S. & Hanson, T. E. Methanotrophic bacteria. *Microbiol. Rev.* **60**, 439–471 (1996).
24. Smith, P. *et al.* Agriculture, Forestry and Other Land Use (AFOLU). *Edenhofer O R Pichs-Madruga Sokona E Farahani Kadner K Seyboth Adler Baum Brunner P Eickemeier B Kriemann J Savol. Schlömer C Von Stechow T Zwickel JC Minx Eds Clim. Change 2014 Mitig. Clim. Change Contrib. Work. Group III Fifth Assess. Rep. Intergov. Panel Clim. Change Camb. Univ. Press Camb. U. K. N. Y. NY USA* (2014).
25. Thomson, A. J., Giannopoulos, G., Pretty, J., Baggs, E. M. & Richardson, D. J. Biological sources and sinks of nitrous oxide and strategies to mitigate emissions. *Philos. Trans. R. Soc. B Biol. Sci.* **367**, 1157–1168 (2012).

26. Hénault, C. *et al.* Management of soil pH promotes nitrous oxide reduction and thus mitigates soil emissions of this greenhouse gas. *Sci. Rep.* **9**, 20182 (2019).
27. Li, C., Frolking, S. & Butterbach-Bahl, K. Carbon Sequestration in Arable Soils is Likely to Increase Nitrous Oxide Emissions, Offsetting Reductions in Climate Radiative Forcing. *Clim. Change* **72**, 321–338 (2005).
28. Sahoo, K. K., Goswami, G. & Das, D. Biotransformation of Methane and Carbon Dioxide Into High-Value Products by Methanotrophs: Current State of Art and Future Prospects. *Front. Microbiol.* **12**, 520 (2021).
29. Cook-Patton, S. C. *et al.* Mapping carbon accumulation potential from global natural forest regrowth. *Nature* **585**, 545–550 (2020).
30. Luo, H. *et al.* Mature semiarid chaparral ecosystems can be a significant sink for atmospheric carbon dioxide. *Glob. Change Biol.* **13**, 386–396 (2006).
31. Veldman, J. W. *et al.* Where Tree Planting and Forest Expansion are Bad for Biodiversity and Ecosystem Services. *BioScience* **65**, 1011–1018 (2015).
32. Lewis, S. L., Wheeler, C. E., Mitchard, E. T. A. & Koch, A. Restoring natural forests is the best way to remove atmospheric carbon. *Nature* **568**, 25–28 (2019).
33. Wheeler, M. M. *et al.* Carbon and nitrogen storage in California sage scrub and non-native grassland habitats. *J. Arid Environ.* **129**, 119–125 (2016).
34. Haidinger, T. L. & Keeley, J. E. Role of High Fire Frequency in Destruction of Mixed Chaparral. *Madroño* **40**, 141–147 (1993).
35. Keeley, J. E. & Syphard, A. D. Historical patterns of wildfire ignition sources in California ecosystems. *Int. J. Wildland Fire* **27**, 781 (2018).
36. Syphard, A. D. *et al.* Human Influence on California Fire Regimes. *Ecol. Appl.* **17**, 1388–1402 (2007).
37. Zedler, P. H., Gautier, C. R. & McMaster, G. S. Vegetation Change in Response to Extreme Events: The Effect of a Short Interval between Fires in California Chaparral and Coastal Scrub. *Ecology* **64**, 809–818 (1983).
38. Mcleod, E. *et al.* A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO_2. *Front. Ecol. Environ.* **9**, 552–560 (2011).
39. Ward, M. A. *et al. Blue Carbon Stocks and Exchanges Along the Pacific West Coast*. https://bg.copernicus.org/preprints/bg-2021-27/bg-2021-27.pdf (2021) doi:10.5194/bg-2021-27.
40. Duarte, C. M. & Krause-Jensen, D. Export from Seagrass Meadows Contributes to Marine Carbon Sequestration. *Front. Mar. Sci.* **4**, (2017).
41. Howard, J. *et al.* Clarifying the role of coastal and marine systems in climate mitigation. *Front. Ecol. Environ.* **15**, 42–50 (2017).
42. Kauffman, J. B. *et al.* Total ecosystem carbon stocks at the marine-terrestrial interface: Blue carbon of the Pacific Northwest Coast, United States. *Glob. Change Biol.* **26**, 5679–5692 (2020).
43. Cameron, D. R., Marvin, D. C., Remucal, J. M. & Passero, M. C. Ecosystem management and land conservation can substantially contribute to California's climate mitigation goals. *Proc. Natl. Acad. Sci.* **114**, 12833–12838 (2017).
44. Keeley, J. E., Safford, H., Fotheringham, C. J., Franklin, J. & Moritz, M. The 2007 Southern California Wildfires: Lessons in Complexity. *J. For.* **107**, (2009).
45. ICF. Sea Level Rise Vulnerability Assessment - Draft. 68 (2019).
46. Lindsey, R. Understanding Climate | Climate Change: Global Sea Level. *NOAA Climate | News and Features* https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level (2021).
47. Kroeger, K. D., Crooks, S., Moseman-Valtierra, S. & Tang, J. Restoring tides to reduce methane emissions in impounded wetlands: A new and potent Blue Carbon climate change intervention. *Sci. Rep.* **7**, 11914 (2017).
48. Southern California Wetlands Recovery Project. *Wetlands on the Edge: The Future of Southern California's Wetlands: Regional Strategy 2018*. (2018).

49. CARB. *California 2030 Natural and Working Lands Climate Change Implementation Plan - January 2019 Draft*. (2019).
50. Batra, P. *Linking Climate-Friendly Farming Practices to San Diego County's Climate Action Plan: An Opportunity Analysis of Carbon Farming in the Unincorporated County*. (2018).
51. Fargione, J. *et al.* Challenges to the Reforestation Pipeline in the United States. *Front. For. Glob. Change* **4**, 629198 (2021).
52. SANDAG. *The 2021 Regional Plan - Appendix AA: Regional Habitat Conservation Vision*. https://sdforward.com/mobility-planning/2021-regional-plan-draft (2021).
53. McTigue, N. D., Walker, Q. A. & Currin, C. A. Refining Estimates of Greenhouse Gas Emissions From Salt Marsh "Blue Carbon" Erosion and Decomposition. *Front. Mar. Sci.* **8**, 661442 (2021).
54. CARB. *An inventory of ecosystem carbon in California's natural and working lands*. (2018).
55. Ward, M. A. *et al.* Blue carbon stocks and exchanges along the California coast. *Biogeosciences* **18**, 4717–4732 (2021).
56. California Department of Food and Agriculture. COMET-Planner California Healthy Soils. http://www.comet-planner-cdfahsp.com/ (2021).
57. Fargione, J. *et al.* Supplementary Materials for: Natural climate solutions for the United States. *Sci. Adv.* **4**, eaat1869 (2018).
58. Richards, C. & Caires, K. *Carbon Farming Plan*. 57 (2018).
59. City of San Diego. *Climate Action Plan 2018 Annual Report Appendix*. (2018).
60. City of San Diego. Sustainability Division | City of San Diego Official Website. https://www.sandiego.gov/2020cap#ourclimate (2021).
61. Hristov, A. N. *et al.* Special topics—Mitigation of methane and nitrous oxide emissions from animal operations: I. A review of enteric methane mitigation options. *J. Anim. Sci.* **91**, 5045–5069 (2013).
62. Pape, D. *et al.* Managing Agricultural Land for Greenhouse Gas Mitigation Within the United States. *US Dep. Agric.* (2016).
63. Skjellerudsveen, M. *Carbon Farm Plan for Angels Farm*. (2018).
64. Elmer, M. Farmers Want to Create San Diego's Carbon Dumps. *Voice of San Diego* https://www.voiceofsandiego.org/topics/science-environment/farmers-want-to-create-san-diegos-carbon-dumps/ (2021).
65. Brevik, E. C. & Homburg, J. A. A 5000 year record of carbon sequestration from a coastal lagoon and wetland complex, Southern California, USA. *CATENA* **57**, 221–232 (2004).
66. Stein, E. D. *et al.* Wetlands of the Southern California coast: Historical extent and change over time. *South. Calif. Coast. Water Res. Proj. Tech. Rep.* **826**, 1–50 (2014).
67. Di Vittorio, A. V., Simmonds, M. B. & Nico, P. Quantifying the effects of multiple land management practices, land cover change, and wildfire on the California landscape carbon budget with an empirical model. *PLOS ONE* **16**, e0251346 (2021).
68. NOAA Office for Coastal Management. Sea Level Rise Data Download. https://coast.noaa.gov/slrdata/ (2017).
69. Walshok, M., Shapiro, J., SelfridgeBustos, G. & Carton, G. *Downtown San Diego: The Innovation Economy's Next Frontier, report for the Downtown San Diego Partnership*. https://extension.ucsd.edu/UCSDExtension/media/UCSDExtensionsMedia/community-and-research/center-for-research-and-evaluation/Downtown-Partnership-Demographic-Study_1.pdf (2015).
70. American Forests. *Urban Ecosystem Analysis San Diego, California: Calculating the Value of Nature*. (2003).
71. McPherson, E. G. *et al.* The structure, function and value of urban forests in California communities. *Urban For. Urban Green.* **28**, 43–53 (2017).

72. U.S. Department of Agriculture, Forest Service. *Urban tree canopy assessment: a community's path to understanding and managing the urban forest*. 16 (2019).
73. Domke, G. M. *et al.* Greenhouse gas emissions and removals from forest land, woodlands, and urban trees in the United States, 1990–2019. *US Dep. Agric. For. Serv. North. Res. Stn.* **Resource Update FS-307**, (2021).
74. SANDAG. Climate Action Portal. https://climatedata.sandag.org/ (2021).
75. Nowak, D. J., Stevens, J. C., Sisinni, S. M. & Luley, C. J. Effects of Urban Tree Management and Species Selection on Atmospheric Carbon Dioxide. 10 (2002).
76. McPherson, E. G., Simpson, J. R., Peper, P. J., Scott, K. I. & Xiao, Q. Tree Guidelines for Coastal Southern California Communities. 106 (2000).
77. Nowak, D. J., Greenfield, E. J., Hoehn, R. E. & Lapoint, E. Carbon storage and sequestration by trees in urban and community areas of the United States. *Environ. Pollut.* **178**, 229–236 (2013).
78. Nowak, D. J., Greenfield, E. J. & Ellis, A. *Climate Change and Urban Forests*. 93 https://d36s8l75ryva2.cloudfront.net/wp-content/uploads/2021/04/Nowak-Study.pdf (2021).
79. Tree Equity Score & American Forests. Tree Equity Score. https://treeequityscore.org/ (2021).
80. Domke, G. M. *et al.* Appendix 1.–National Scale Estimates for Individual States, 1990-2019 in Domke, Grant M.; Walters, Brian F.; Nowak, David J.; Smith, James, E.; Nichols, Michael C.; Ogle, Stephen M.; Coulston, J.W.; Wirth, T.C. 2021. Greenhouse gas emissions and removals from forest land, woodlands, and urban trees in the United States, 1990-2019. Resource Update FS-307. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station. 5 p. [plus 2 appendixes]. https://doi.org/10.2737/FS-RU-307. (2021).
81. The Nature Conservancy California. Nature-Based Climate Solutions. https://tnc.maps.arcgis.com/apps/webappviewer/index.html?id=b6386378560a4c0496d5d0edafe56ce8 (2020).
82. Riley, C. B. & Gardiner, M. M. Examining the distributional equity of urban tree canopy cover and ecosystem services across United States cities. *PLOS ONE* **15**, e0228499 (2020).

Appendix 4.A.1 – Carbon stock and flow data and sources for section 4.2 – Land Use.

Values used to multiply polygon area by vegetation type are shown in Table 4.A.1.

Table 4.A.1. Carbon stock and flux multipliers by Holland vegetation class type and the sources.

LEGEND	C stock (MT CO_2e ha^{-1})	C flux (MT CO_2e $ha^{-1}yr^{-1}$)	Category
11000 Non-Native Vegetation	19[1]	0.01[2]	Disturbed
11200 Disturbed Wetland	235[3]	-1.07[4]	Wetland
11300 Disturbed Habitat	19[1]	0.01[2]	Disturbed
12000 Urban/Developed	7.66[5]	0.388507[6,7]	Settlement
18000 General Agriculture	37[8]	0.383[8]	Agriculture
18100 Orchards and Vineyards	37[8]	0.383[8]	Agriculture
18200 Intensive Agriculture - Dairies, Nurseries, Chicken Ranches	37[8]	0.383[8]	Agriculture
18300 Extensive Agriculture - Field/Pasture, Row Crops	37[8]	0.383[8]	Agriculture
18310 Field/Pasture	37[8]	0.383[8]	Agriculture
18320 Row Crops	37[8]	0.383[8]	Agriculture
21230 Southern Foredunes	0.15[9]	0	Desert
22100 Active Desert Dunes	0.15[9]	0	Desert
22300 Stabilized and Partially-Stabilized Desert Sand Field	0.15[9]	0	Desert
24000 Stabilized Alkaline Dunes	0.15[9]	0	Desert
25000 Badlands/Mudhill Forbs	0.15[9]	0	Desert
31200 Southern Coastal Bluff Scrub	43[1]	1.91[2]	Scrub
32000 Coastal Scrub	43[1]	1.91[2]	Scrub
32400 Maritime Succulent Scrub	43[1]	1.91[2]	Scrub
32500 Diegan Coastal Sage Scrub	43[1]	1.91[2]	Scrub
32510 Diegan Coastal Sage Scrub: Coastal form	43[1]	1.91[2]	Scrub
32520 Diegan Coastal Sage Scrub: Inland form	43[1]	1.91[2]	Scrub
32700 Riversidian Sage Scrub	43[1]	1.91[2]	Scrub
32710 Riversidian Upland Sage Scrub	43[1]	1.91[2]	Scrub
32720 Alluvial Fan Scrub	43[1]	1.91[2]	Scrub
33000 Sonoran Desert Scrub	43[1]	1.91[2]	Scrub
33100 Sonoran Creosote Bush Scrub	43[1]	1.91[2]	Scrub
33200 Sonoran Desert Mixed Scrub	43[1]	1.91[2]	Scrub
33210 Sonoran Mixed Woody Scrub	43[1]	1.91[2]	Scrub
33220 Sonoran Mixed Woody and Succulent Scrub	43[1]	1.91[2]	Scrub
33230 Sonoran Wash Scrub	43[1]	1.91[2]	Scrub
33300 Colorado Desert Wash Scrub	43[1]	1.91[2]	Scrub
33600 Encelia Scrub	43[1]	1.91[2]	Scrub
33700 Acacia Scrub	43[1]	1.91[2]	Scrub
34000 Mojavean Desert Scrub	43[1]	1.91[2]	Scrub
34300 Blackbush Scrub	43[1]	1.91[2]	Scrub

35000 Great Basin Scrub	43[1]	1.91[2]	Scrub
35200 Sagebrush Scrub	43[1]	1.91[2]	Scrub
35210 Big Sagebrush Scrub	43[1]	1.91[2]	Scrub
36110 Desert Saltbush Scrub	43[1]	1.91[2]	Scrub
36120 Desert Sink Scrub	43[1]	1.91[2]	Scrub
37000 Chaparral	43[1]	1.91[2]	Scrub
37120 Southern Mixed Chaparral	43[1]	1.91[2]	Scrub
37121 Granitic Southern Mixed Chaparral	43[1]	1.91[2]	Scrub
37122 Mafic Southern Mixed Chaparral	43[1]	1.91[2]	Scrub
37130 Northern Mixed Chaparral	43[1]	1.91[2]	Scrub
37131 Granitic Northern Mixed Chaparral	43[1]	1.91[2]	Scrub
37132 Mafic Northern Mixed Chaparral	43[1]	1.91[2]	Scrub
37200 Chamise Chaparral	43[1]	1.91[2]	Scrub
37210 Granitic Chamise Chaparral	43[1]	1.91[2]	Scrub
37220 Mafic Chamise Chaparral	43[1]	1.91[2]	Scrub
37300 Red Shank Chaparral	43[1]	1.91[2]	Scrub
37400 Semi-Desert Chaparral	43[1]	1.91[2]	Scrub
37500 Montane Chaparral	43[1]	1.91[2]	Scrub
37510 Mixed Montane Chaparral	43[1]	1.91[2]	Scrub
37520 Montane Manzanita Chaparral	43[1]	1.91[2]	Scrub
37530 Montane Ceanothus Chaparral	43[1]	1.91[2]	Scrub
37540 Montane Scrub Oak Chaparral	43[1]	1.91[2]	Scrub
37800 Upper Sonoran Ceanothus Chaparral	43[1]	1.91[2]	Scrub
37830 Ceanothus crassifolius Chaparral	43[1]	1.91[2]	Scrub
37900 Scrub Oak Chaparral	43[1]	1.91[2]	Scrub
37A00 Interior Live Oak Chaparral	43[1]	1.91[2]	Scrub
37C30 Southern Maritime Chaparral	43[1]	1.91[2]	Scrub
37G00 Coastal Sage-Chaparral Transition	43[1]	1.91[2]	Scrub
37K00 Montane Buckwheat Scrub	43[1]	1.91[2]	Scrub
39000 Upper Sonoran Subshrub Scrub	43[1]	1.91[2]	Scrub
42000 Valley and Foothill Grassland	19[1]	0.01[2]	Grassland
42100 Native Grassland	19[1]	0.01[2]	Grassland
42110 Valley Needlegrass Grassland	19[1]	0.01[2]	Grassland
42120 Valley Sacaton Grassland	19[1]	0.01[2]	Grassland
42200 Nonnative Grassland	19[1]	0.01[2]	Grassland
42200 Non-Native Grassland	19[1]	0.01[2]	Grassland
42210 Non-Native Grassland: Broadleaf-Dominated	19[1]	0.01[2]	Grassland
42300 Wildflower Field	19[1]	0.01[2]	Grassland
42400 Foothill/Mountain Perennial Grassland	19[1]	0.01[2]	Grassland
42470 Transmontane Perennial Grassland	19[1]	0.01[2]	Grassland
44000 Vernal Pool	151[3,10]	0[11,12]	Wetland
44320 San Diego Mesa Vernal Pool	151[3,10]	0[11,12]	Wetland

44322 San Diego Mesa Claypan Vernal Pool	151[3,10]	0[11,12]	Wetland
45000 Meadows and Seeps	19[1]	0.01[2]	Grassland
45100 Montane Meadow	19[1]	0.01[2]	Grassland
45110 Wet Montane Meadow	19[1]	0.01[2]	Grassland
45120 Dry Montane Meadows	19[1]	0.01[2]	Grassland
45300 Alkali Meadows and Seeps	19[1]	0.01[2]	Grassland
45320 Alkali Seep	19[1]	0.01[2]	Grassland
45400 Freshwater Seep	19[1]	0.01[2]	Grassland
46000 Alkali Playa Community	19[1]	0.01[2]	Grassland
52120 Southern Coastal Salt Marsh	235[3]	2.18[14]	Wetland
52300 Alkali Marsh	235[3]	2.18[14]	Wetland
52310 Cismontane Alkali Marsh	235[3]	2.18[14]	Wetland
52400 Freshwater Marsh	151[3,10]	1.4[10]	Wetland
52410 Coastal and Valley Freshwater Marsh	151[3,10]	1.4[10]	Wetland
52420 Transmontane Freshwater Marsh	151[3,10]	1.4[10]	Wetland
52440 Emergent Wetland	151[3,10]	1.4[10]	Wetland
60000 Riparian and Bottomland Habitat	100[15]	4.3[16]	Riparian
61000 Riparian Forests	100[15]	4.3[16]	Riparian
61300 Southern Riparian Forest	100[15]	4.3[16]	Riparian
61310 Southern Coast Live Oak Riparian Forest	100[15]	4.3[16]	Riparian
61320 Southern Arroyo Willow Riparian Forest	100[15]	4.3[16]	Riparian
61330 Southern Cottonwood-Willow Riparian Forest	100[15]	4.3[16]	Riparian
61510 White Alder Riparian Forest	100[15]	4.3[16]	Riparian
61810 Sonoran Cottonwood-Willow Riparian Forest	100[15]	4.3[16]	Riparian
61820 Mesquite Bosque	100[15]	4.3[16]	Riparian
62000 Riparian Woodlands	100[15]	4.3[16]	Riparian
62200 Desert Dry Wash Woodland	135[2]	3.67[2]	Woodlands
62300 Desert Fan Palm Oasis Woodland	135[2]	3.67[2]	Woodlands
62400 Southern Sycamore-Alder Riparian Woodland	135[2]	3.67[2]	Woodlands
62500 Southern Riparian Woodland	135[2]	3.67[2]	Woodlands
63000 Riparian Scrubs	135[2]	3.67[2]	Woodlands
63300 Southern Riparian Scrub	135[2]	3.67[2]	Woodlands
63310 Mule Fat Scrub	135[2]	3.67[2]	Woodlands
63320 Southern Willow Scrub	135[2]	3.67[2]	Woodlands
63321 Arundo donnax Dominant/Southern Willow Scrub	135[2]	3.67[2]	Woodlands
63400 Great Valley Scrub	135[2]	3.67[2]	Woodlands
63410 Great Valley Willow Scrub	135[2]	3.67[2]	Woodlands
63800 Colorado Riparian Scrub	135[2]	3.67[2]	Woodlands
63810 Tamarisk Scrub	135[2]	3.67[2]	Woodlands
63820 Arrowweed Scrub	135[2]	3.67[2]	Woodlands
64000 Unvegetated Habitat	0	0	Barren
64100 Open Water	0	0	Water

64110 Marine	0	0	Water
64111 Subtidal	0	0	Water
64112 Intertidal	0	0	Water
64121 Deep Bay	0	0	Water
64122 Intermediate Bay	0	0	Water
64123 Shallow Bay	0	0	Water
64130 Estuarine	0	0	Water
64131 Subtidal	0	0	Water
64133 Brackishwater	0	0	Water
64140 Freshwater	0	0	Water
64200 Non-Vegetated Channel or Floodway	0	0	Water
64300 Saltpan/Mudflats	231[3]	2[3]	Wetland
64400 Beach	0	0	Barren
70000 Woodland	135[2]	3.67[2]	Woodlands
71000 Cismontane Woodland	135[2]	3.67[2]	Woodlands
71100 Oak Woodland	135[2]	3.67[2]	Woodlands
71120 Black Oak Woodland	135[2]	3.67[2]	Woodlands
71160 Coast Live Oak Woodland	135[2]	3.67[2]	Woodlands
71161 Open Coast Live Oak Woodland	135[2]	3.67[2]	Woodlands
71162 Dense Coast Live Oak Woodland	135[2]	3.67[2]	Woodlands
71180 Engelmann Oak Woodland	135[2]	3.67[2]	Woodlands
71181 Open Engelmann Oak Woodland	135[2]	3.67[2]	Woodlands
71182 Dense Engelmann Oak Woodland	135[2]	3.67[2]	Woodlands
72300 Peninsular Pinon and Juniper Woodlands	135[2]	3.67[2]	Woodlands
72310 Peninsular Pinon Woodland	135[2]	3.67[2]	Woodlands
72320 Peninsular Juniper Woodland and Scrub	135[2]	3.67[2]	Woodlands
75100 Elephant Tree Woodland	135[2]	3.67[2]	Woodlands
77000 Mixed Oak Woodland	135[2]	3.67[2]	Woodlands
78000 Undifferentiated Open Woodland	135[2]	3.67[2]	Woodlands
79000 Non-Native Woodland	135[2]	3.67[2]	Woodlands
79100 Eucalyptus Woodland	135[2]	3.67[2]	Woodlands
81100 Mixed Evergreen Forest	155[2]	8.87[2]	Forests
81300 Oak Forest	155[2]	8.87[2]	Forests
81310 Coast Live Oak Forest	155[2]	8.87[2]	Forests
81320 Canyon Live Oak Forest	155[2]	8.87[2]	Forests
81340 Black Oak Forest	155[2]	8.87[2]	Forests
83140 Torrey Pine Forest	155[2]	8.87[2]	Forests
83230 Southern Interior Cypress Forest	155[2]	8.87[2]	Forests
84000 Lower Montane Coniferous Forest	155[2]	8.87[2]	Forests
84100 Coast Range, Klamath and Peninsular Coniferous Forest	155[2]	8.87[2]	Forests
84140 Coulter Pine Forest	155[2]	8.87[2]	Forests
84150 Bigcone Spruce (Bigcone Douglas Fir)-Canyon Oak Forest	155[2]	8.87[2]	Forests

84230 Sierran Mixed Coniferous Forest	155[2]	8.87[2]	Forests
84500 Mixed Oak/Coniferous/Bigcone/Coulter Forest	155[2]	8.87[2]	Forests
85100 Jeffrey Pine Forest	155[2]	8.87[2]	Forests

Appendix 4.A.1 works cited

1. Wheeler, M. M. *et al.* Carbon and nitrogen storage in California sage scrub and non-native grassland habitats. *J. Arid Environ.* **129**, 119–125 (2016).
2. Cameron, D. R., Marvin, D. C., Remucal, J. M. & Passero, M. C. Supporting Information for Ecosystem management and land conservation can substantially contribute to California's climate mitigation goals. *Proc. Natl. Acad. Sci.* **114**, 12833–12838 (2017).
3. Ward, M. A. *et al.* Blue carbon stocks and exchanges along the California coast. *Biogeosciences* **18**, 4717–4732 (2021).
4. McTigue, N. D., Walker, Q. A. & Currin, C. A. Refining Estimates of Greenhouse Gas Emissions From Salt Marsh "Blue Carbon" Erosion and Decomposition. *Front. Mar. Sci.* **8**, 661442 (2021).
5. Bjorkman, J. *et al.* Biomass, Carbon Sequestration, and Avoided Emissions: Assessing the Role of Urban Trees in California. (2015).
6. Reforestation Hub - Reforestation Opportunities for Climate Change Mitigation. https://www.reforestationhub.org/.
7. Cook-Patton, S. C. *et al.* Lower cost and more feasible options to restore forest cover in the contiguous United States for climate mitigation. *One Earth* **3**, 739–752 (2020).
8. Zhu, Z.-L. & Reed, B. C. *Baseline and projected future carbon storage and greenhouse-gas fluxes in ecosystems of the Western United States*. (US Geological Survey, 2012).
9. Ayala-Niño, F. *et al.* Spatial distribution of soil carbon storage in desert shrubland ecosystems of northwest Mexico. *J. Arid Environ.* **183**, 104251 (2020).
10. Bernal, B. & Mitsch, W. J. Comparing carbon sequestration in temperate freshwater wetland communities. *Glob. Change Biol.* **18**, 1636–1647 (2012).
11. Kifner, L. H., Calhoun, A. J. K., Norton, S. A., Hoffmann, K. E. & Amirbahman, A. Methane and carbon dioxide dynamics within four vernal pools in Maine, USA. *Biogeochemistry* **139**, 275–291 (2018).
12. Fennessy, M. S., Wardrop, D. H., Moon, J. B., Wilson, S. & Craft, C. Soil carbon sequestration in freshwater wetlands varies across a gradient of ecological condition and by ecoregion. *Ecol. Eng.* **114**, 129–136 (2018).
13. Reed, C. C. *et al.* Montane Meadows: A Soil Carbon Sink or Source? *Ecosystems* **24**, 1125–1141 (2021).
14. Mcleod, E. *et al.* A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO_2. *Front. Ecol. Environ.* **9**, 552–560 (2011).
15. Dybala, K. E. *et al.* Optimizing carbon storage and biodiversity co-benefits in reforested riparian zones. *J. Appl. Ecol.* **56**, 343–353 (2019).
16. California Department of Food and Agriculture. COMET-Planner California Healthy Soils. http://www.comet-planner-cdfahsp.com/ (2021).

Appendix 4.A.2. Blue carbon methodology details and carbon value sources for section 4.5.

The "ECO_VEGETATION_CN" layer contains polygons for all land use types as well as water types. In order to only consider the impacts of sea level rise on blue carbon habitats, the vegetation layer was filtered to only contain those blue carbon polygons.

Two rounds of filtering occurred. First, polygons were filtered by the broad vegetation categories (column name: "CATEGORY") of 'Bog and Marsh' and 'Riparian and Bottomland Habitat.' In order to additionally include degraded wetlands, which still hold carbon, the Holland code and name (column name: "LEGEND") of '11200 Disturbed Wetland.'

Next, these broader categories were filtered to only remove the following Holland code polygons, because they were not considered blue carbon habitats in this analysis: '64400 Beach,' '64112 Intertidal,' '64000 Unvegetated Habitat,' '64110 Marine,' '64111 Subtidal,' '64121 Deep Bay,' '64122 Intermediate Bay,' '64123 Shallow Bay,' '64131 Subtidal,' '64140 Freshwater,' and '64200 Non-Vegetated Channel or Floodway.' What remained were the blue carbon habitat polygons.

The resulting layer was clipped using NOAA's 1 foot SLR layer (fixed and reprojected to ESPG:6414) such that the resulting layer only showed those blue carbon habitats that would be inundated with seawater under a 1 foot SLR scenario. Area was calculated in QGIS and the final attribute table was exported as a CSV file for carbon emissions and lost sequestration potential calculations in Excel. Values used are shown in Table S4.2.

Table 4.A.2. Carbon values and sources used to calculate lost carbon stock and sequestration rates.

Blue Carbon Habitat Type		**Stock (MT CO_2e ha^{-1})**	**Flow (MT CO_2e $ha^{-1}yr^{-1}$)**
Freshwater marsh		151[xvii]	1.4[1]
Mudflats/Saltpans		231[2]	2[3]
Riparian scrub/estuary		100[4]	4.3[5]
Salt marsh/estuary		235[2]	2.18[6]

Appendix 4.A.2 works cited:

1. Bernal, B. & Mitsch, W. J. Comparing carbon sequestration in temperate freshwater wetland communities. *Glob. Change Biol.* **18**, 1636–1647 (2012).
2. Ward, M. A. *et al.* Blue carbon stocks and exchanges along the California coast. *Biogeosciences* **18**, 4717–4732 (2021).
3. Sasmito, S. D. *et al.* Organic carbon burial and sources in soils of coastal mudflat and mangrove ecosystems. *CATENA* **187**, 104414 (2020).
4. Dybala, K. E. *et al.* Optimizing carbon storage and biodiversity co-benefits in reforested riparian zones. *J. Appl. Ecol.* **56**, 343–353 (2019).
5. California Department of Food and Agriculture. COMET-Planner California Healthy Soils. http://www.comet-planner-cdfahsp.com/ (2021).
6. Mcleod, E. *et al.* A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO_2. *Front. Ecol. Environ.* **9**, 552–560 (2011).

[xvii] Assumes that freshwater marsh storage follows the same ratio to saltwater marsh storage (Ward et al., 2021) as freshwater marsh sequestration (from Bernal & Mitsch, 2012) does to saltwater marsh sequestration (Mcleod et al., 2011).

5. Decarbonization of Buildings

Philip Eash-Gates, Synapse Energy Economics, Inc.
Jason Frost, Synapse Energy Economics, Inc.
Shelley Kwok, Synapse Energy Economics, Inc.
Jackie Litynski, Synapse Energy Economics, Inc.
Kenji Takahashi, Synapse Energy Economics, Inc.
Asa Hopkins, PhD, Synapse Energy Economics, Inc.

Key Takeaways

- Reducing emissions from space heating and water heating should be a primary policy focus for buildings within the Regional Decarbonization Framework.
- Policies should support increasing adoption of efficient heat pump-based space and water heating systems in both new and existing buildings, with particular focus on assistance for low-income residents and rental buildings
- Some existing fossil fuel equipment systems will only turn over once by 2050. Near-term action is needed to guide building owners away from replacing end-of-life fossil fuel equipment with like
- Low-carbon gaseous fuels can be used for hard-to-electrify end uses, though research and piloting is required
- Stranded cost risk is mitigated by minimizing unnecessary extensions or replacements of the gas pipeline system and by accelerating depreciation of existing utility assets.
- Improved data gathering is a low-cost, foundational action for future policy development

San Diego County is the fifth most populous county in the United States[1] and boasts a large and diverse building stock.[2] The unique geography and varied climates within the San Diego region have helped create an architectural montage, with distinct attributes across the county's 18 municipalities and unincorporated areas.[3,4] The local infrastructure is also shaped in part by the county's 18 Native American tribal reservations[5,6]—the most in any US county—and 16 military bases.[7] While it is one of the county's great assets, the building stock is also a key contributor to emissions: on-site fossil fuel combustion was responsible for about 300,000 metric tons of carbon dioxide-equivalent emissions in 2014 or about 9 percent of the county's total emissions.[8] Decarbonizing existing and new buildings in the San Diego region will be a critical strategy within the Regional Decarbonization Framework. This chapter is focused on direct emissions from buildings, resulting from the combustion of fossil fuels, and what it would take to eliminate those emissions by 2045. Emissions from electricity generation are addressed in Chapter 2 of this report.

Options for decarbonizing San Diego's buildings include electrifying end uses that are responsible for direct emissions, primarily space and water heating, and using lower-carbon fuels such as biomethane and hydrogen. The relative costs of pathways taking different approaches are similar, within the range of uncertainty. However, electrification-based approaches are generally lower-risk because they do not depend on technological innovation or the deployment of novel technologies at previously unseen scales.

All building decarbonization pathways cause a substantial change in the gas utility business, due to changes in the amount and sources of the gas sold. Electrification pathways, in particular, would require fundamental changes in the gas utility business model because traditional pipeline gas sales would be virtually eliminated by mid-century. We conclude this chapter with an analysis of some simple near-term steps that San Diego Gas & Electric, its regulators, and regional policymakers could take to mitigate risks associated with this transition and thereby make it easier to develop a long-term business transition plan.

5.1 Buildings in San Diego County

Residential Buildings

There are an estimated 1.3 million residential units across 0.9 million properties in San Diego County. These residences comprise approximately 1.7 billion square feet and are growing at a rate of 0.9 percent per year. [xviii] The relative sizes of the residential building stock vary considerably by municipality, as depicted in Figure 5.1. The City of San Diego and the unincorporated areas of the county represent 57 percent of the total. The City and County therefore have a large opportunity to reduce emissions in this sector through targeted policies, such as building energy codes.

[xviii] Synapse analysis of data provided by San Diego County Assessor's Office.

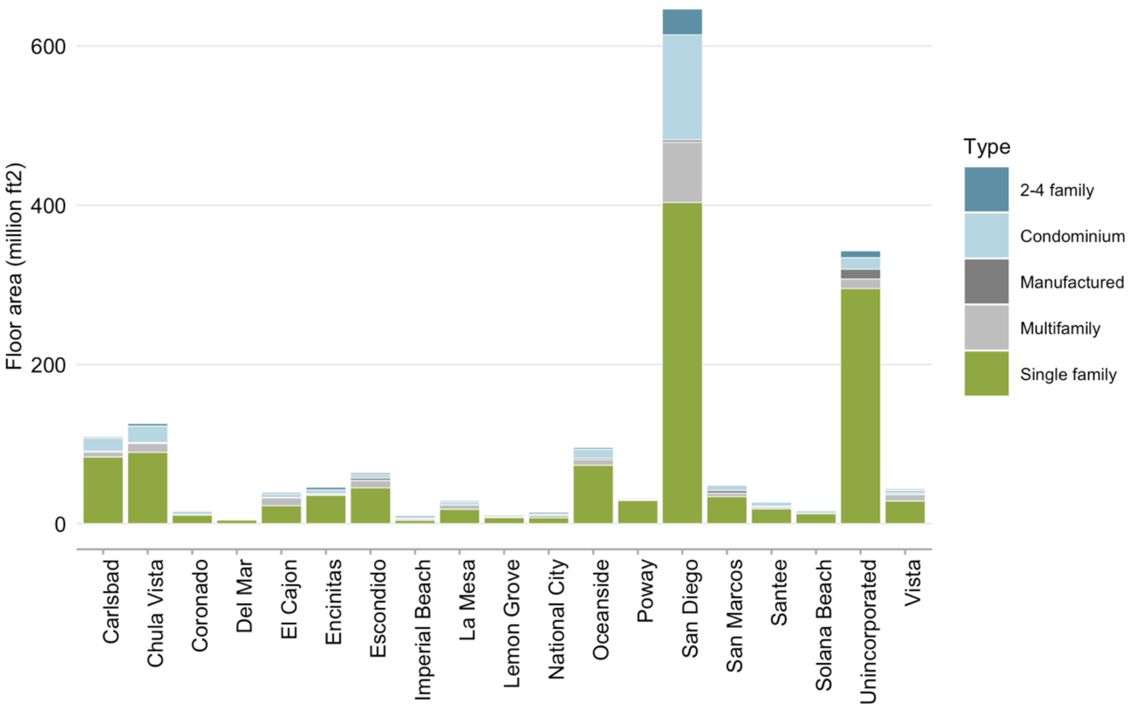


Figure 5.1. Residential building stock by municipality in San Diego County, 2021. Source: Synapse analysis of data provided by San Diego County Assessor's Office.

Figure 5.2 provides a breakdown of the building stock by type of residence and over time for each jurisdiction. These distinctions may affect how quickly and at what cost a community will be able to decarbonize its buildings. Strategies for addressing emissions for single family homes will differ from strategies for multifamily apartments due to differing ownership/occupancy paradigms and types of end-use energy equipment in the residences. Additionally, for communities with the fastest relative growth rates—which have recently been Imperial Beach, National City, Chula Vista, San Marcos, and Santee—more stringent building energy codes can play an important role locally.

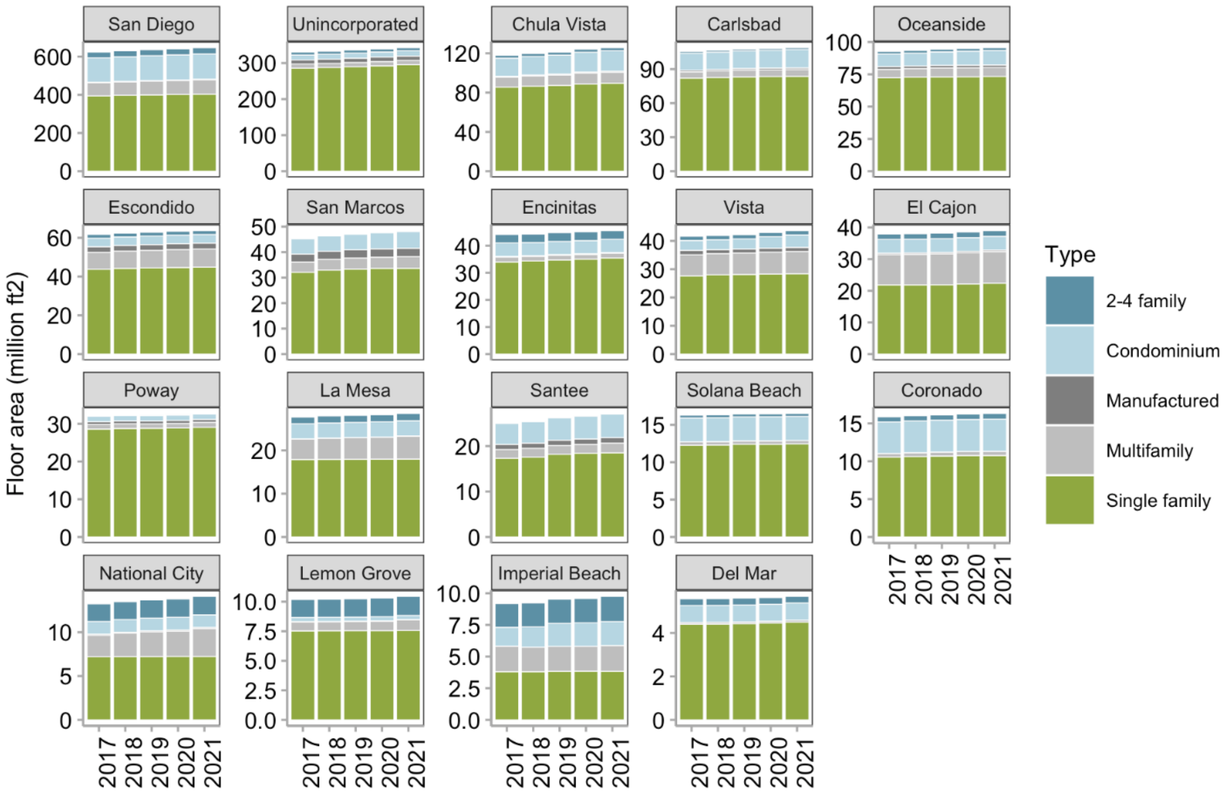


Figure 5.2. Residential building stock by municipality in San Diego County, 2017–2021. Source: Synapse analysis of data provided by San Diego County Assessor's Office.

Figure 5.3 provides a breakdown of the average pipeline gas usage for each major gas end use by residential customers under three investor-owned utilities, based on the latest *Residential Appliance Saturation Study*.[9xix] As shown in this figure, the average gas usage for water heating is 200 therms and accounts for the largest share (about 59 percent) of the total usage for the major end uses in San Diego Gas & Electric's (SDG&E's) jurisdiction. This share is much larger than the water heating usage share for PG&E, but very close to the usage share for SoCalGas. On the other hand, the average residential gas usage for space heating in the SDG&E area accounts for about 29 percent. These gas end use profiles show that SDG&E residential customers have the greatest opportunity for GHG savings in water heating. Lastly, a jurisdictional comparison of the total gas usage data in this figure shows that households in San Diego County are in more favorable positions to pursue building decarbonization because 1)

[xix] Note that while this figure excludes minor end uses with low customer saturations such as spa and pool heat, secondary heating, and gas backup for solar water heaters, the average natural gas consumption among all gas customers is lower than the estimates shown in this figure because some customers do not use gas for all major end uses.

their overall gas usage is lower and 2) it is easier for customers to reduce GHGs associated with water heating than space heating.

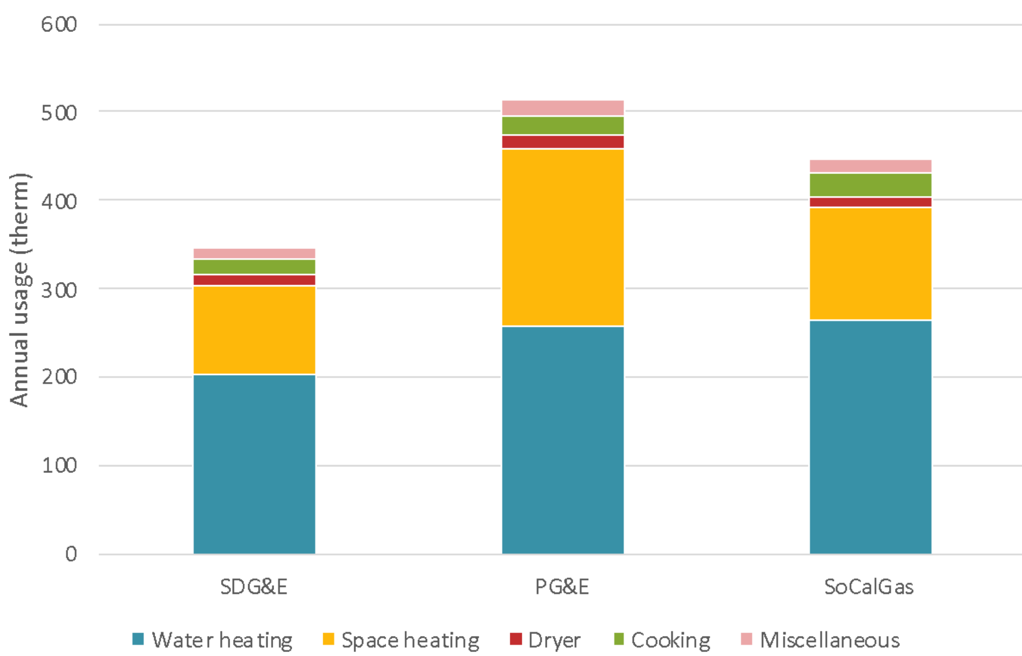


Figure 5.3. Average natural gas usage by end use and by utility for households who use gas as the primary fuel for major end uses. Source: DNV GL Energy Insights. 2021. 2019 California Residential Appliance Saturation Study (RASS).

Figure 5.4 presents residential fuel-use breakdowns for space and water heating end uses in terms of the number of utility accounts in San Diego County. Data for this analysis was based on the 2019 RASS study. As shown in Figure 5.4, natural gas is the dominant fuel for both space and water heating, while its share for water heating (about 83 percent) is more dominant than for space heating (about 69 percent). Approximately 28 percent of total households use electric space heating, while electric water heating is used less than half as much: about 12 percent.

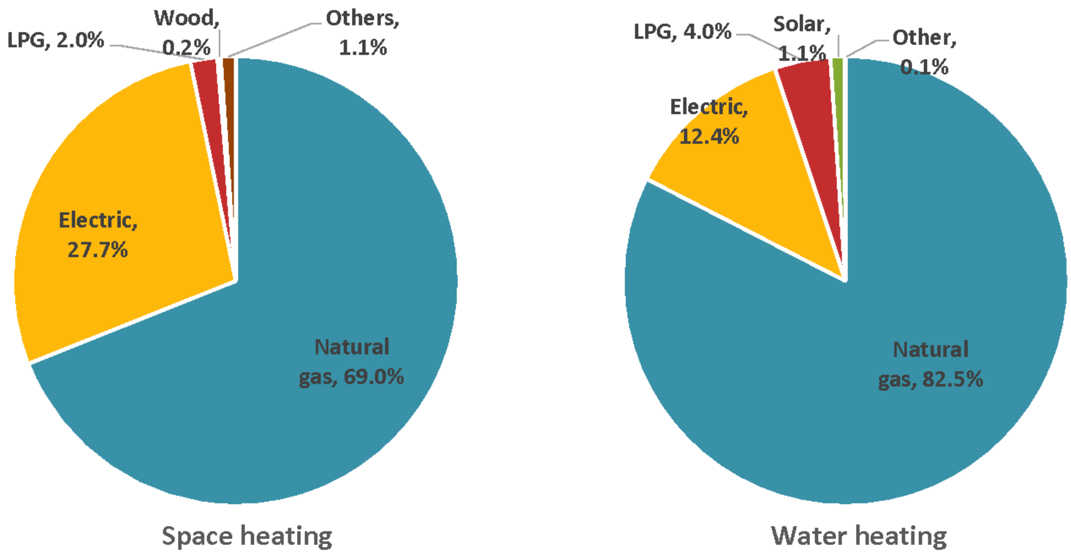


Figure 5.4. Residential space and water heating by fuel type (% of customer accounts).
Source: DNV GL Energy Insights. 2021. 2019 California Residential Appliance Saturation Study (RASS).

Figure 5.5 shows the breakdown of residential space heating equipment in terms of the number of utility accounts in SDG&E's service area (which has a nearly perfect overlap with San Diego County). Electric heat pumps account for about 6.3 percent of all residential systems. Central gas furnaces with ducts account for about 56 percent of the total systems. Three other heating systems that use ducts are central electric and LPG furnaces, and ducted air-source heat pumps (ASHPs). Together, the systems relying on ducts account for about 70 percent of the total residential space heaters. Excluding ducted ASHPs, such systems account for 66 percent of the total. These represent the prime candidates for fuel switching to ducted ASHP technologies. The rest of the space heaters, including electric unit heater (13 percent) and other fossil heaters (about 13.6 percent), can be converted to heat pumps through the use of ductless minisplit heat pumps.

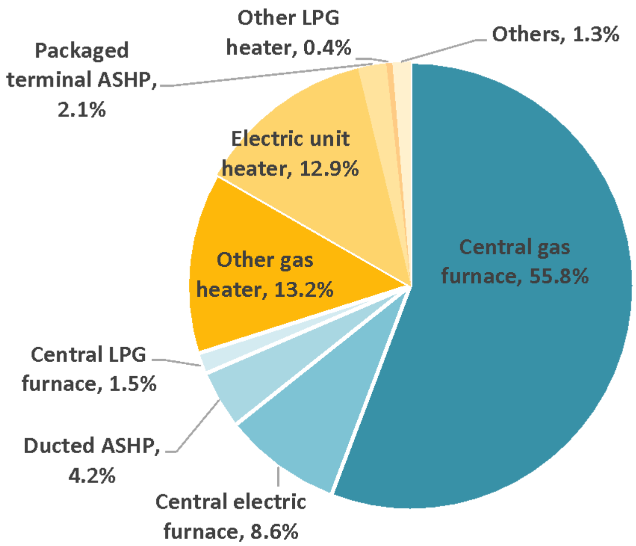


Figure 5.5. Residential space heating system share by equipment type. Source: DNV GL Energy Insights. 2021. 2019 California Residential Appliance Saturation Study (RASS).

Commercial Buildings

The commercial sector includes 158,000 building units across 36,000 properties in the county. Together, these properties represent an estimated 554 million square feet and are growing at a rate of 0.9 percent per year.[xx] Figure 5.6 highlights the relative sizes of the commercial building stock in each area within the county. The City of San Diego, the unincorporated areas of the county, Chula Vista, Carlsbad, Escondido, and Oceanside have the largest total floor areas. Given the sizable stock of commercial buildings in the City of San Diego, its policies can have an outsized effect on reducing emissions. The City's Building Energy Benchmarking Ordinance is an important step toward managing energy use and emissions in large buildings.[10] The ordinance lays the foundation for future innovative policies such as building performance standards, which establish mandatory energy or emissions targets that improve over time.[xxi]

[xx] Synapse analysis of data provided by San Diego County Assessor's Office.

[xxi] The following resources provide additional information on building performance standards:

American Cities Climate Challenge. 2021. *Building Performance Standards: A framework for Equitable Policies to Address Existing Buildings*. Available at: https://www.usdn.org/uploads/cms/documents/bps-framework_july-2021_final.pdf.

American Council for Energy-Efficient Economy. 2020. *Mandatory Building Performance Standards: A Key Policy for Achieving Climate Goals.* Available at: https://www.aceee.org/white-paper/2020/06/mandatory-building-performance-standards-key-policy-achieving-climate-goals.

Carbon Neutral Cities Alliance. 2020. Existing Building Performance Standards Targets and Metrics Final Report. Available at: http://carbonneutralcities.org/wp-content/uploads/2020/03/CNCA-Existing-Building-Perf-Standards-Targets-and-Metrics-Memo-Final-March2020.pdf

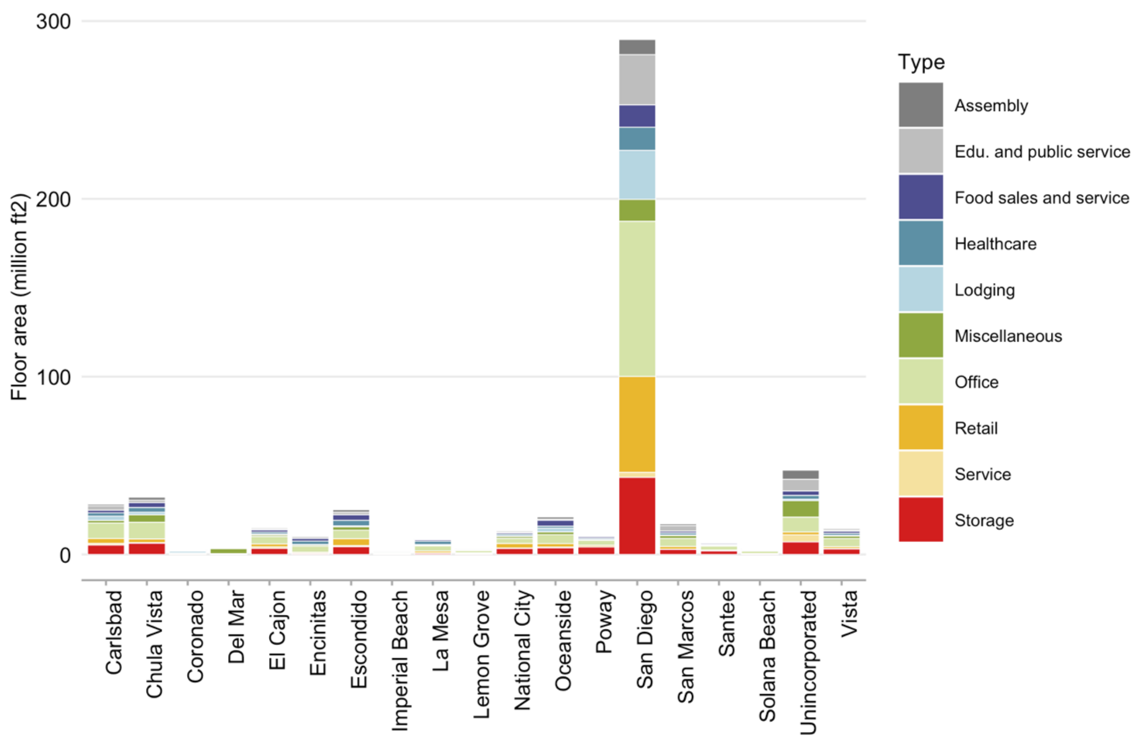


Figure 5.6. Commercial building stock by municipality in San Diego County, 2021. Source: Synapse analysis of data provided by San Diego County Assessor's Office.

The prominence of each commercial building type and the growth rate of the commercial building stock varies by location and over time, as shown in Figure 5.7. As with residential buildings, these distinctions will influence the jurisdictions' pathways to decarbonization. Some building types (*e.g.*, hospitals and restaurants) are more difficult to retrofit with equipment that reduces carbon emissions, particularly from onsite combustion of fossil fuels. Carlsbad, Imperial Beach, and San Marcos are experiencing higher rates of growth.

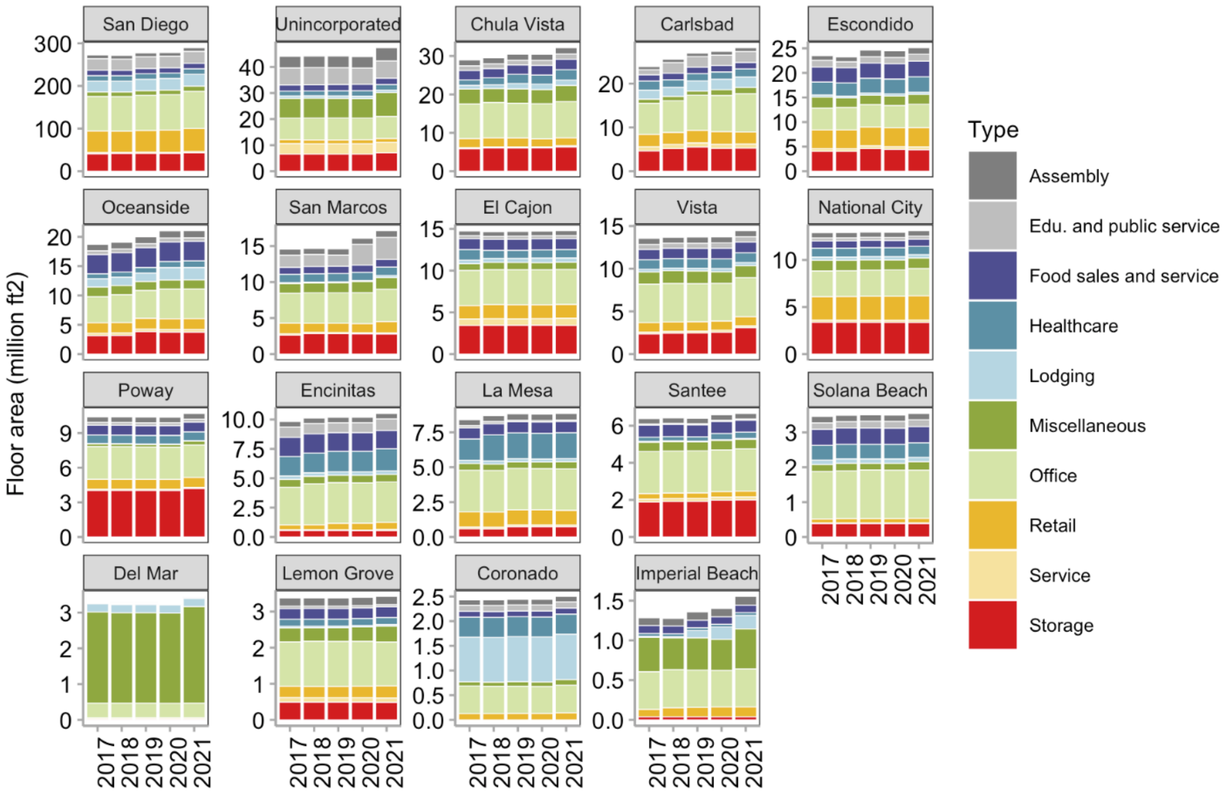


Figure 5.7. Commercial building stock by municipality in San Diego County, 2017–2021. Source: Synapse analysis of data provided by San Diego County Assessor's Office

Fossil fuel combustion is the main source of GHG emissions for buildings. Fuel is consumed onsite to provide services such as space heating, water heating, and cooking. Additionally, electricity, district heating, and district cooling are generated offsite using fossil-based fuels, and the associated emissions are attributable to buildings that use these utilities. To identify strategies for reducing these emissions in San Diego County, it is important to first understand the fuel use in local buildings—both how much of each fuel is used and what it is used for. Using data from SDG&E, the City of San Diego,[11] the San Diego County Assessor's Office, the U.S. Energy Information Administration,[12] and prior energy studies,[13,14] Synapse estimated the fuel, energy, and emission profiles for buildings in the San Diego region. Figure 5.8 presents the results for each building type and across the total commercial building stock.

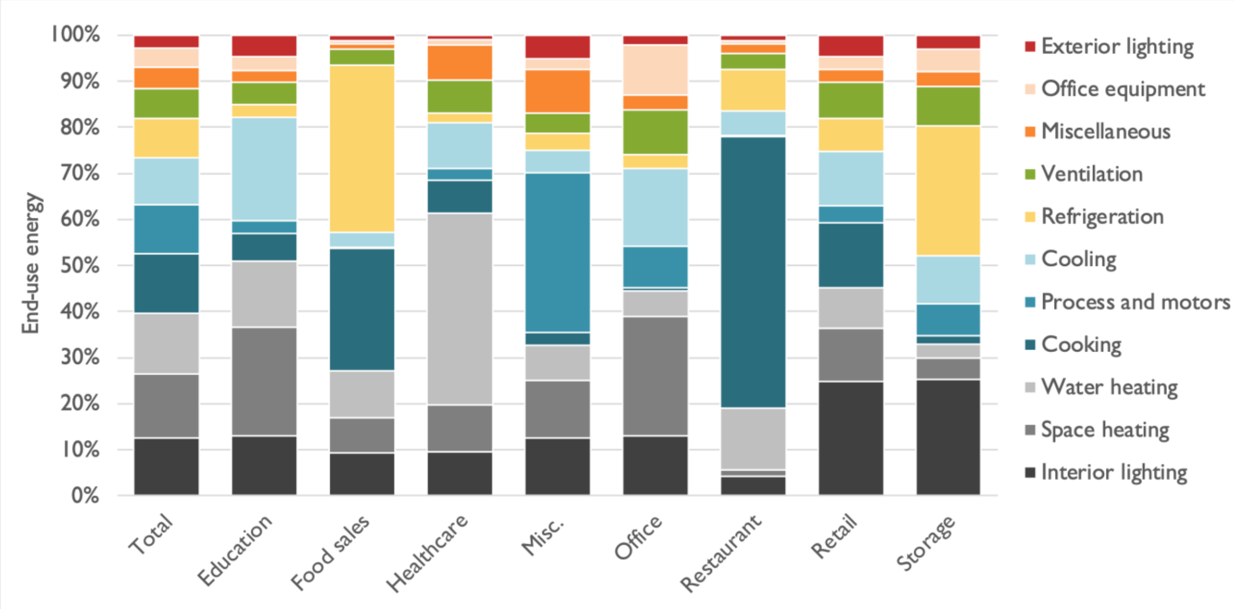


Figure 5.8. San Diego County energy end-use profiles by building type. Source: Synapse model

Space heating and water heating are the two end uses responsible for the most greenhouse gases in San Diego County. This is in part because they require large amounts of energy—together over a quarter of all energy used in commercial buildings in the county—and in part because they rely heavily on fossil fuels, specifically natural gas. Figure 5.9 provides a breakdown of the primary fuel used for space and water heating in commercial buildings. Additionally, end uses that rely on electricity will have fewer emissions over time as the electric grid incorporates more renewable generation. These facts together suggest that reducing emissions from space heating and water heating should be a primary policy focus within the Regional Decarbonization Framework. The existing types of equipment within a building plays an important role in determining what strategies will be most effective when decarbonizing a building. A breakdown of existing equipment types for space and water heating is provided in Figure 5.10 for commercial buildings in San Diego County.

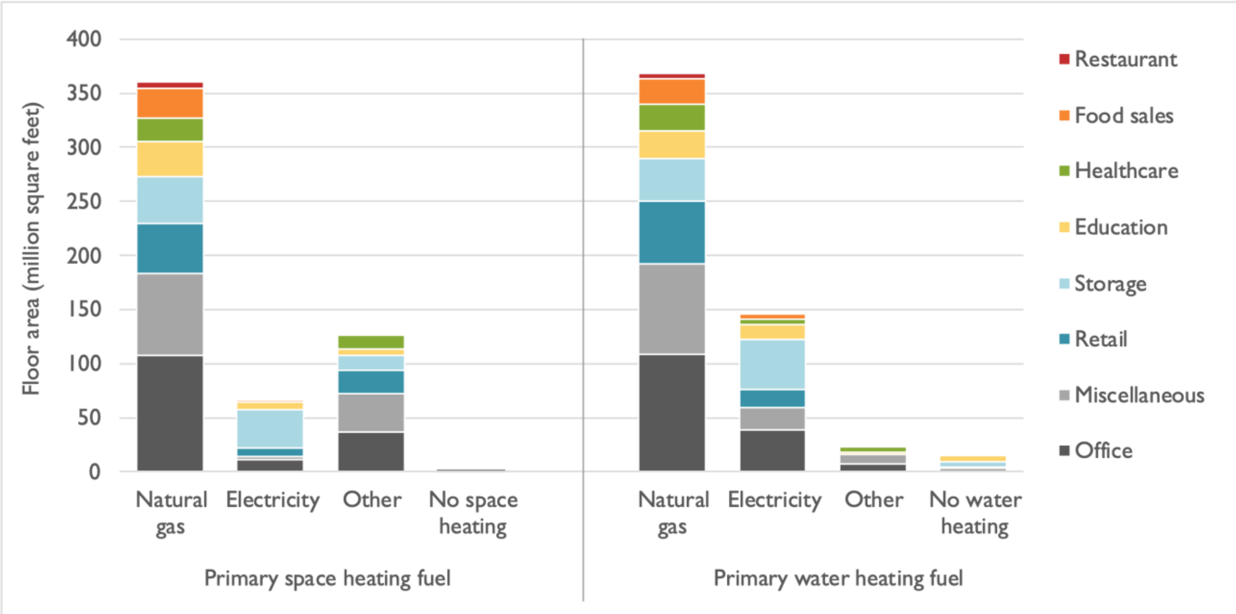


Figure 5.9. San Diego County primary fuel by building type: space heating and water heating. Source: Synapse model.

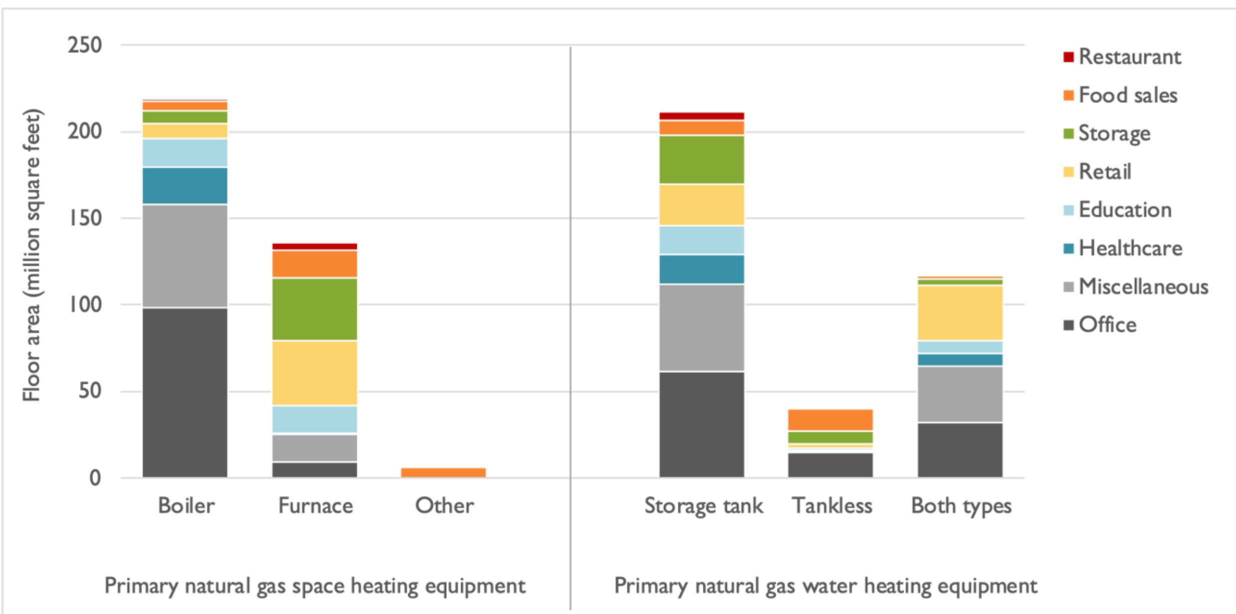


Figure 5.10. San Diego County natural gas equipment system by building type: space heating and water heating. Source: Synapse model.

5.2 Technologies and Fuels for Decarbonizing Buildings

Space heating technologies

Electric heat pumps are energy-efficient heating and cooling systems that work for all climates. Unlike fossil fuel-based heaters that generate heat by burning fuels, heat pumps provide space heating by extracting heat from outside and transferring it to the inside, using a vapor-compression refrigerant cycle connecting an outdoor compressor with an indoor heat exchanger. Heat pumps also work as an efficient air conditioner by reversing the heat transfer process to remove heat and moisture from the indoor air. Because of this heat transfer process, heat pump efficiency levels typically go over 250 percent (or a coefficient of performance (COP) of 2.5) for heating and 400 percent (or a COP of 4) for cooling. That means for one unit of energy input, a heat pump can provide 2.5 or more units of heating. By comparison, the most efficient gas heaters provide 0.98 units of heating for one unit of energy input.

Various types of heat pumps are available in the market. Heat pumps are primarily categorized by (a) the heat sources they draw from to heat buildings, (b) whether the systems heat air or water, and (c) how the extracted heat is distributed in the buildings. Primary heat pump technologies used for space heating include air-source heat pumps (ASHPs), ground-source heat pumps (GSHPs), water-source heat pumps (WSHPs), and air-to-water heat pump (AWHPs).

ASHPs are the most common heat pump system type used in the country. They move heat in the air between inside and outside. Because ASHPs use heat in the outdoor air, their performance (in terms of efficiency and capacity) degrades in cold temperatures. Thus, conventional ASHPs often have back-up electric resistance heating strips for cold temperature operation. However, cold climate ASHPs that are now widely available in the market can provide comfortable heat even under freezing temperatures without a backup heater.[xxii] Notably, the winter climate in the populated regions of San Diego County is very moderate, so there is little need for backup heat.

ASHPs include ducted ASHPs, mini-split ductless heat pumps, packaged terminal heat pumps, and variable refrigerant flow (VRF) ASHPs. A short summary of these technologies is provided below.

[xxii] A field study in Vermont observed that cold climate ASHPs operated at 5 F with a COP of 1.6 and even at -20F at above 1 COP. See Cadmus. 2017. *Evaluation of Cold Climate Heat Pumps in Vermont*. Prepared for the Vermont Public Service Department. Page 24. Available at: https://publicservice.vermont.gov/sites/dps/files/documents/Energy_Efficiency/Reports/Evaluation%20of%20Cold%20Climate%20Heat%20Pumps%20in%20Vermont.pdf.

- **Ducted ASHPs** are the most widely installed systems. Ducted ASHPs include split systems and packaged systems. Split heat pumps have an outdoor condenser and an air handling unit in the building to deliver heating or cooling through ducts similar to forced-air gas furnaces. Packaged heat pumps have all the components necessary for heating, cooling, and air circulation combined into a single system, usually mounted directly onto the building. They are typically installed on rooftops and thus are often called rooftop units (RTUs). Ducted ASHPs can be a suitable alternative to aging gas furnaces. Ducted ASHPs are installed in residential and small to medium commercial buildings.
- **Mini-split ductless heat pumps** are relatively new to the U.S. market but have been gaining popularity over the past several years as new residential and small commercial heating systems across the country. Mini-split systems also have outdoor condensers but use refrigerant pipes to deliver heating or cooling to each room where an indoor unit is installed. Because they use small refrigerant pipes and are relatively easy to install, they are suitable for heating system retrofits where ducts are not available. They also use variable speed compressors, which allow them to operate more efficiently and quietly than standard ducted ASHPs and to provide superior temperature controls.
- **Packaged terminal heat pumps (PTHP)** are all-in-one systems (including compressor, condenser and evaporator coils, fans, etc.), installed on an exterior wall. They are often installed in hotels and small apartment units. Compared to other heat pump systems, PTHPs do not perform well, and their operating temperatures are typically limited. However, a few cold climate PTHP models recently have become available in the market.[15]
- **Variable refrigerant flow (VRF) ASHPs** can distribute heating and cooling to numerous indoor evaporator units through a main refrigerant line from a single outdoor system.[16] Many VRFs can also provide heating and cooling simultaneously in different rooms by adding a heat recovery system, and thus are beneficial for buildings with diversely loaded zones.[17] VRFs are generally suitable for medium to large commercial buildings, but especially for medium/high-rise multifamily buildings, office, schools, and lodging.[18]

Compared with ASHP, GSHPs and WSHPs provide better performance in cold temperatures because they use heat reservoirs that have a higher temperature than ambient air during the winter.[xxiii] GSHPs use underground rock or groundwater as a heat reservoir. WSHPs use a well, lake, aquifer, or other source (*e.g.*, wastewater, cooling loop system, etc.) as a heat reservoir. GSHPs need to drill holes or dig trenches in the ground to install a heat exchanging group loop and thus are considerably more expensive than other heat pump technologies; however, total lifecycle costs for GSHPs can sometimes be lower, due to high-efficiency operation.

[xxiii] GSHPs and WSHPs also typically provide better cooling performance in hot temperatures because the heat reservoirs are generally lower temperature than ambient air during the summer.

AWHPs extract heat in the outdoor air and use water (or a mixture of water and glycol) as a heat transfer medium within the building instead of forced air. AWHPs are now widely available as heat pump water heaters for residential buildings. To date, their applications for space heating have been limited in the United States, although more systems are becoming commercially available in the early 2020s. For large commercial buildings with existing hot water heating systems (*e.g.*, with gas boilers), large-scale AWHPs can be a more energy-efficient alternative heating system or can provide supplemental heating.

GSHP, WSHPs, and even AWHPs can also produce temperatures high enough for a district heating energy system that circulates hot water. For example, Stanford University's new district heating energy system includes three large-scale heat recovery chillers (a type of WSHPs) that extract heat from waste heat from the University's cooling tower.[19]

Heat pump performance

For our building energy analysis, we developed average annual COP values for heat pumps separately for the residential and commercial buildings for a Reference case and for a Low Demand (high efficiency) case, as shown in Table 5.1 below. We developed these estimates based on our assessment of various data sources. The data sources include our own calculation of COP values based on real-world heat pump performance data on residential-scale heat pumps in other states, combined with hourly temperatures in San Diego County.[20, 21] We also reviewed COP values in California[22] and for the US market as a whole.[23] For commercial buildings, we assumed that heat pumps are 20 percent more efficient than residential systems under the Reference Case due to the availability of high-temperature heat sources, VRF's high COP values due to simultaneous heating and cooling functions, and advanced technologies such as multi-stage compressors. Finally, we developed projections of COP values through 2050 for the Reference case and for the Low Demand (high efficiency) case based on National Renewable Energy Laboratory's COP forecasts in its *Electrification Futures Study*.[24]

Table 5.1. Synapse projection of COP values for heat pump space heating in San Diego.

	2021	**2030**	**2040**	**2050**
Reference case				
Residential	3.3	3.6	3.8	3.8
Commercial	3.9	4.4	4.5	4.6
Low Demand case				
Residential	3.3	3.8	4.4	5.0
Commercial	3.9	4.5	5.0	5.5

We also developed our forecasts of total installed costs for heat pumps and gas space heaters for single-family and multifamily buildings, as shown in Table 5.2 below. We reviewed numerous data sources and developed the current cost estimates primarily based on a 2019 study by E3 which analyzed residential building electrification in California.[25] The main reasons why we decided to use this data source are that (a) some of the cost estimates in this study aligned well with our knowledge of system installed costs and the cost estimates in other data sources we trust; (b) the study conducted a detailed bottom up approach to estimate heat pump costs; and (c) the study provided cost estimates by climate zone, type of building, and building vintage. We selected cost estimates for coastal LA and downtown LA to develop cost estimates for San Diego County, as these areas have the most similar climate to San Diego. We then developed various factors using various data sources to develop weighted average cost estimates for single-family and multifamily buildings in San Diego County.[xxiv] We then forecasted future total installed costs of these systems using data from NREL's *Electrification Future Study*. Finally, we used the share of floor area between single-family and multifamily buildings (*i.e.*, 54 percent single-family and 46 percent multifamily) to develop per-unit costs for residential buildings on average, to align with how our decarbonization scenarios are defined. Equipment costs do not differ substantially between new construction and retrofits, provided that retrofits do not include changes in ductwork. (We assume that ducted systems are replaced with ducted, to avoid such costs.) Given San Diego's mild winters and prevalence of air conditioning, we do not expect electric panel upgrades to be required to adapt efficient electric space or water heating in typical homes.

[xxiv] We used the following sources to develop new construction and HVAC retrofit rates: Joint Center for Housing Studies of Harvard University. 2021. *Improving America's Housing*. Available at: https://www.jchs.harvard.edu/sites/default/files/reports/files/harvard_jchs_improving_americas_housing_2021.pdf; Statista. 2021. "Number of housing units in the United States from 1975 to 2020. Accessed September 27, 2021. Available at: https://www.statista.com/statistics/240267/number-of-housing-units-in-the-united-states/; San Diego County's tax assessor database. We also developed an estimate of HVAC retrofits by homes with ductless heaters (*e.g.*, wall furnace, electric resistance heater etc.) in San Diego Country based on the 2019 RASS.

Table 5.2. Synapse projection of average total installed costs of residential HP and gas space heaters in San Diego ($2021).

	2021	**2030**	**2040**	**2050**
Heat pump				
Single family	$14,200	$13,142	$11,967	$10,791
Multifamily	$10,900	$10,088	$9,186	$8,284
All residential	$12,673	$11,728	$10,680	$9,631
Gas heater				
Single family	$15,000	$15,000	$15,000	$15,000
Multifamily	$11,400	$11,400	$11,400	$11,400
All residential	$13,334	$13,334	$13,334	$13,334

Table 5.3 provides estimated building electrification costs for commercial buildings in San Diego County. These include costs to convert existing fossil-based systems to electric systems, as well as related building infrastructure changes. Energy efficiency retrofits, such as building envelope upgrades to reduce the peak-load impact of electrification, are not included. We draw on data from a 2021 building electrification study for Los Angeles,[26] heat pump cost trajectories from NREL's *Electrification Futures Study*,[24] and 2021 data on building characteristics from the San Diego County Tax Assessor's Office. We adjusted these data to align with the local building stock. Our economic analysis in Section 7.2 below is based on costs to electrify space and water heating (and does not yet include other end uses, the cost to disconnect gas, or potential costs to upgrade electrical service).

Table 5.3. Estimated commercial building electrification costs for San Diego County ($2021).

Item	**Units**	**2021**	**2030**	**2035**	**2040**	**2045**	**2050**
Space heat	*$/sqft*	$15.83	$13.79	$13.03	$12.28	$11.80	$11.33
Water heat	*$/sqft*	$0.65	$0.57	$0.53	$0.49	$0.46	$0.42
Cooking	*$/sqft kitchen*	$18.00	$18.00	$18.00	$18.00	$18.00	$18.00
Gas disconnection	*$/property*	$922	$922	$922	$922	$922	$922
Electrical upgrades	*$/property*	$32,975	$32,975	$32,975	$32,975	$32,975	$32,975
Other end uses, misc.	*$/sqft*	$1.75	$1.75	$1.75	$1.75	$1.75	$1.75

Source: Synapse model based on data from Jones (2021), Mai et al. (2018), and San Diego County Tax Assessor's Office (2021).

Water heating technologies

As mentioned in the previous section, residential water heating is the largest gas consuming end use and thus offers the largest GHG emissions savings opportunity through electrification of this end use.

Heat pump water heaters (HPWHs) have now become widely available in the market. The most popular HPWH technology is a hybrid HPWH which includes heat pumps, back up electric resistance coils, and hot water storage tanks. HPWHs are very efficient water heating systems. Their efficiency is measured using a Uniform Energy Factor (UEF) which presents an efficiency rating based on certain testing conditions.[xxv] The majority of the available products have UEFs above 3, and several products with a UEF of 4 are now available in the market.[27] Hybrid HPWHs can be installed in many places, including garages, basements, back porches, and outdoor-vented closets. Depending on where they are installed, their performance differs widely because of differences in air temperature and ventilation. In California, a garage is an optimal place for the best performance in warmer climates like San Diego, while basements may be a better place in northern parts of the state.[28]

Another HPWH technology is a split heat pump water heater with an outdoor compressor, sometimes called a "pure" HPWH because it does not need a backup resistance heater. Because it is a split system, it offers more flexibility for placing the indoor unit within the living space. Sanden produces a split HWPH that uses CO_2 as a refrigerant. This split heat pump water heater has several advantages over hybrid models: (a) it has a substantially higher capacity (approximately 3 times larger than hybrid models) and efficiency (with a rated COP of 5), (b) it only requires 13 Amp service, which could avoid upgrading an electrical panel (while a few new hybrid HPWH models also only require 15 Amps or so), and (c) it can raise water temperature up to 175 F and can operate in ambient temperatures down to -20 F.[29]

Both hybrid and pure HPWHs can offer load flexibility and work as demand response resources by storing additional thermal energy when electricity rates low to avoid energy usage during peak hours. A 2018 study by Ecotope, Inc. found that this HPWH load flexibility can result in customer bill savings of 15 to 20 percent, with about 35 percent utility marginal cost savings in California.[30]

Several large-scale HPWHs (which are either AWHPs or WSHPs) are available for commercial buildings in the market (including large multifamily buildings), though to-date, such applications have been limited in the country. HPWH configurations for commercial buildings can be quite

---

[xxv] UEF is comparable to coefficient of performance: it measures the ratio of the energy service output to the energy input. It is not exactly equal to the coefficient of performance for a water heater's heating element because it incorporates heat losses from the water storage tank.

different from single-family homes because commercial buildings have a lot of variations in water use and building structures, and also because some buildings have unique opportunities to utilize different heat reservoirs. For example, HPWHs can be placed in a below-grade garage, if available, and take advantage of the milder temperatures in the garage to produce hot water.[31] Mechanical rooms or laundry rooms can also be a suitable place for HPWHs installations if such those rooms are currently too hot or too humid, because HPWHs have the added benefit of cooling and dehumidifying the surrounding air. Further, HPWHs can be placed where they can utilize waste heat produced in certain commercial facilities such as spas, restaurant kitchens, or wastewater treatment facilities. Such HPWH applications provide space cooling benefits to the commercial facilities. Finally, large commercial and institutional buildings with a standard chiller system with a cooling tower could be a good candidate for installing HPWHs, more specifically heat recovery chillers. Heat recovery chillers can recover some of the waste heat from the electric chillers and produce hot water.[32]

Water heater performance

For our building energy analysis, we developed average annual COP values for HPWH separately for residential and commercial buildings for a Reference case and for a Low Demand (high efficiency) case, as shown in Table 7.4 below. We developed these values based on our assessment of a few different data sources. The primary source is NRDC and Ecotope's analysis of HPWH performance in California, where they estimated COP values in 16 climate zones in the state.[28] We selected climate zones suitable for San Diego County from this study and estimated the average COP values for garage and vented closet placement. We then adjusted the COP values upward to account for the technology improvement, since the study was conducted using the UEF ratings for the currently available HPWH products.[27] Finally, we developed our COP projections and COP estimates for commercial systems loosely based on NREL's COP forecasts for HWPH in its *Electrification Futures Study*.[24] NREL's COP estimates for commercial systems are generally lower than residential systems, with the difference ranging from 0 percent to about 14 percent, depending on the years. However, we assume commercial systems perform at least as well as residential systems and better than NREL's projections because some commercial buildings have access to unique heat reservoirs, unlike residential buildings.

Table 5.4. Synapse' projection of COP values for heat pump water heating in San Diego.

	2021	2030	2040	2050
Reference case				
Residential	3.0	3.2	3.5	3.5
Commercial	3.0	3.2	3.5	3.5
Low Demand case				
Residential	3.0	3.3	3.6	4.0
Commercial	3.0	3.3	3.6	4.0

We also developed our forecasts of total installed costs for HPWHs and gas water heaters for single family and multifamily buildings, as shown in Table 7.5 below. We first developed the current cost estimates based on a literature review of a few different sources.[33] We then forecasted future total installed costs of these systems using data from NREL's *Electrification Future Study*. Finally, we used the share of floor area between single-family and multifamily buildings (*i.e.*, 54 percent single-family and 46 percent multifamily) to develop per-unit costs for residential buildings on average, to align with how our decarbonization scenarios are defined. As with space heating, we do not find that costs differ substantially between new construction and retrofit applications.

Table 5.5. Synapse projection of total installed costs of residential HPWHs and gas water heaters in San Diego ($2021).

	2021	2030	2040	2050
Heat pump water heater				
Single family	$3,000	$2,500	$2,037	$1,852
Multifamily	$2,125	$1,771	$1,443	$1,312
All residential	$2,595	$2,162	$1,762	$1,602
Gas water heater				
Single family	$1,650	$1,375	$1,120	$1,019
Multifamily	$1,600	$1,333	$1,086	$988
All residential	$1,627	$1,356	$1,105	$1,004

Cost data for water heating electrification for commercial buildings, including installing HPWHs, are provided in Table 5.3 above.

Cooking technologies

While cooking with fossil fuels is a relatively small contributor to GHG emissions in most homes, these end uses are also those which residents most directly see and engage with fuel combustion. Many people enjoy cooking with gas on the stovetop, especially when compared with older electric technologies. Consumers are generally less attached to a particular fuel for ovens, and almost every other cooking appliance (such as microwaves, slow cookers, and pressure cookers) is natively electric.

In the residential sector, cooking is therefore more important for the economics and pathways of decarbonization because it relates to whether residents retain a gas connection for their home, even after switching fuels for water and space heating, than it is as a source of GHG emissions. Aside from restaurants or other food preparation businesses, most commercial buildings have no or almost no cooking related GHG emissions. However, cooking is a larger component of GHG emissions in the commercial sector than it is in residential, due to high energy use in commercial kitchens and lower overall demand for hot water and space heating in commercial buildings.

New electric cooking technologies, particularly cooktops that heat using induction, have the potential to upend customer devotion to cooking with gas. Induction cooking works by using magnetic fields to excite electric currents to swirl inside the pots and pans used for cooking. This is more efficient than older cooking technologies because the pan is directly heated, with no waste heat lost into the room. Heat can be turned up and down very quickly, so heat levels can be changed as fast or faster than gas, and water commonly boils faster on an induction cooktop than a comparable gas one. The cooktop itself stays cool, which improves safety and makes cleanup easy. There are also no combustion emissions, so indoor and outdoor air quality is improved. Electric ovens are comparably priced competitors to gas ovens, and do not face technology-specific market or customer adoption barriers.

Barriers to the adoption of induction cooking include relatively higher upfront prices, the fact that some pots and pans are not compatible with induction, and customer unfamiliarity with the new technology. Both electric cooktops and ovens (and combined systems) can require new electric circuits to be run to carry enough power, and could even trigger the need for an electric panel upgrade (if the panel has not yet been upgraded to serve a fast electric vehicle charger and/or heat pump systems).

Laundry

Electric dryers have a large market share today; in the Pacific census region, the U.S. EIA found that two-thirds of homes that have dryers use an electric one.[34] Aside from potential building-specific barriers stemming from electric-panel capacity and new circuits, there are no substantial barriers to residential adoption of electric dryers. There are also new, more efficient, electric dryers that use heat pump technology. These pump heat into the drum, while the cool side of the heat pump is used to condense the water removed from the clothes. This eliminates the need for a vent, so heat pump dryers can be used very effectively in high-performance buildings with tight building envelopes. Heat pump dryers are gentler on clothes than traditional tumble dryers but can also take a longer time to dry a load of laundry and are currently substantially more expensive than traditional dryers.

Commercial laundry systems face higher barriers to the adoption of electric options than do residential. Running many large electric dryers, as in a laundromat, could require substantial upgrades to a building's electric system if the laundry is transitioning from gas equipment. The slower speed of heat pump dryers is also more of a challenge in throughput-limited commercial laundry systems than in residential applications.

Low-carbon fuels

One way to reduce the GHG emissions from buildings without changing building systems (or before changing those systems to non-emitting options) is to use a fuel that does not release net greenhouse gases into the atmosphere. The two primary ways to generate such a fuel are to process the waste from biological processes or to separate hydrogen from various feedstocks.

Biomethane

Biomethane is defined as methane recovered from or generated from a biological process. (Methane is the primary component of fossil natural gas.) Many microbes that digest organic matter in the absence of oxygen ("anaerobic" digestion) release a combination of carbon dioxide and methane, called syngas. Biological feedstock can also be gasified into syngas using high heat processes (called "pyrolysis"). The carbon dioxide can be removed (called "scrubbing" the gas), leaving pipeline-quality methane.

Biomethane supply is currently very limited, and supply is expected to remain limited to well below the level of current fossil gas consumption. This limitation comes from both the lack of infrastructure to produce biomethane from biological feedstocks and the more fundamental limitation of the amount of feedstock biomass material that can be sustainably produced. In the face of limited supply, use in the building sector may not be prudent or economical because other sectors (such as industrial use) that have fewer low-carbon alternatives may require all the available supply. Processing for pipeline use must also compete with the option to combust the unprocessed (or less processed) fuels at their site of production to generate electricity and transport the resulting low-carbon energy to customers that way. There are also concerns about leakage of biomethane and recovered methane. Fugitive emissions can be high in certain production processes, including digestate storage and biogas upgrading.[35]

Biomethane costs and emissions depend on the production pathway used. In general, though, biomethane has lower, but non-zero, greenhouse gas emissions (especially after leakage is considered), and costs range between $10 per MMBTU to over $50 per MMBTU.[36] (For reference, fossil natural gas currently costs less than $5 per MMBTU.)

Hydrogen-based fuels

There are two primary methods used to produce low-carbon hydrogen. The first of these is electrolysis, in which water is split into hydrogen and oxygen by running electricity through the water. If the electricity for this purpose is low-carbon, then the hydrogen is low-carbon. This is referred to as “green” hydrogen. The second method builds on today’s methods for making hydrogen, which rely on splitting methane into carbon dioxide and hydrogen using “steam reformation.” So-called “blue” hydrogen is low-carbon if the resulting carbon dioxide is captured and permanently sequestered. There are no fundamental physical limits to the amount of “green” hydrogen that can be produced, so this energy carrier holds promise to meet combustion energy needs not met by biomethane.

Hydrogen can be blended with natural gas up to the level of about 20 percent by volume, or 7 percent by energy, without requiring changes in pipeline or customer infrastructure. However, at higher hydrogen concentrations, some pipeline materials could be damaged and customer appliances might fail to work safely. Using pure hydrogen (or high-hydrogen blends) would therefore require a substantial infrastructure investment to replace pipes and ensure that all customer cooktops, furnaces, water heaters, etc., were upgraded before the gas were sent to their buildings. Because hydrogen-ready appliances are only just being tested today, and pipeline systems would also need to be upgraded, this change-over is arguably a larger shift for customers than electrification would be.

One way to limit the need for infrastructure change to accommodate hydrogen would be to combine the hydrogen with carbon captured from a biological source or from direct air capture, to produce synthetic methane. When using biological sources, this fuel would face the same feedstock limits as biomethane. This means that for wholesale replacement of fossil natural gas with synthetic gas, the carbon would likely need to be captured from the air. Net lifecycle GHGs from these processes would depend on powering the air capture with zero-carbon sources of energy and limiting the leakage of the produced methane to low-enough levels so as to not fully counteract the climate benefits of the fuel.

One planning implication of using green hydrogen, especially paired with direct air capture, is the immense requirements for electricity to power the electrolysis and air capture processes. The amount of electricity to produce these fuels and meet customer needs would dwarf the amount of electricity that would be required to directly meet customer needs with the generated electricity. As shown in Figure 5.11, meeting the same energy demand with green hydrogen as with heat pumps would require almost six times as much renewable energy generation.

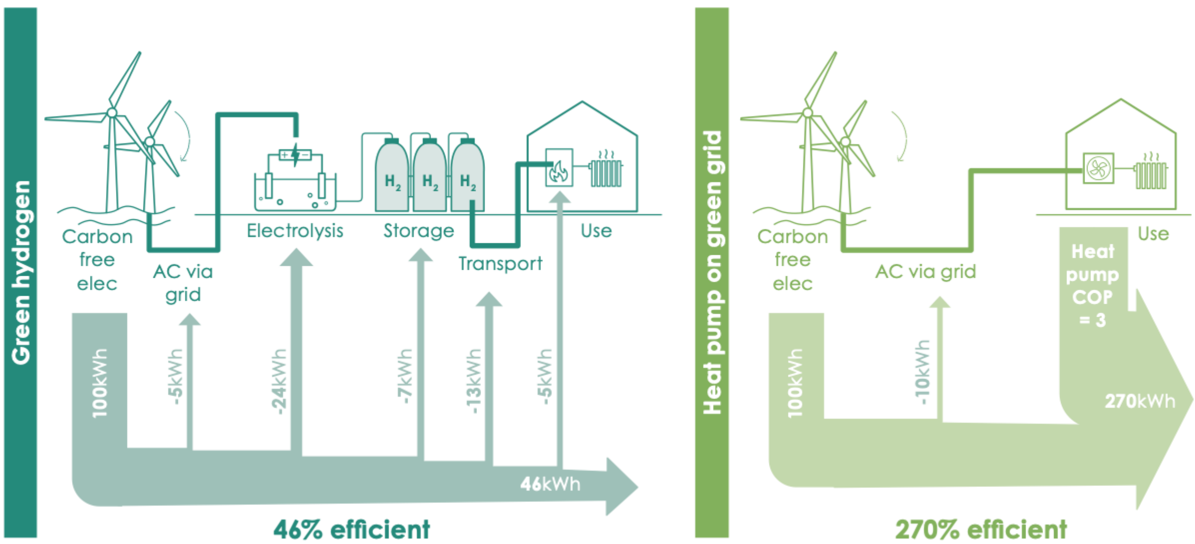


Figure 5.11. Comparison of efficiency of energy delivery between green hydrogen and heat pumps. Note that this figure does not include the added cost and efficiency loss from direct air capture and the manufacture of synthetic methane. Source: London Energy Transformation Initiative, 2021. "Hydrogen: A decarbonisation route for heat in buildings?," Available at: https://b80d7a04-1c28-45e2-b904-e0715cface93.filesusr.com/ugd/252d09_54035c0c27684afca52c7634709b86ec.pdf. Reproduced with permission.

While the ability to store and ship hydrogen and synthetic methane allows the generation to be located in distant places, and not be aligned with seasonal needs for heating, the added land use and cost associated with this electricity production should not be overlooked. Overall, synthetic natural gas is expected to be more expensive than biomethane when using direct air capture: E3 recently estimated a cost of about $70 per MMBTU.[37]

In the San Diego context, with the county's good year-round renewable electricity resource and lack of strong seasonal heating demand, these technologies face an even greater competitive challenge.

5.3. Pathways to Decarbonization of San Diego's Buildings

Synapse modeled three different trajectories to reach a carbon-free building sector in 2050. These scenarios were designed to align with multi-sector analysis performed by Evolved Energy Research, as detailed in Chapter 1 and Appendix A.[xxvi]

1. **Central (High Electrification).** This pathway assumes that over 95 percent of space heating and water heating equipment sales are fully electric by 2030 and 2032, respectively. In 2050, no residential water heating is served by gas and only 8 percent of residential space heating systems are unelectrified.
2. **Low Demand.** In this scenario, space and water heating system sales and stock numbers closely match the trajectories from the Central case. Heat pumps are assumed to perform at higher efficiencies, reducing electricity consumption.
3. **Partial Electrification.** This case models an alternative approach, where less than half of space and water systems sales in 2030 are electric. In this case, a low-carbon gas to use as a natural gas alternative is required to achieve decarbonization within the study period. The scenario assumes a linear increase in the use of a low-carbon gas,[xxvii] starting in 2030 and reaching 100 percent in 2045 and later years.

Table 5.6. Some of the important differences between the three modeled scenarios.

	Central	Low Demand	Partial Electrification
Electric space heat equipment sales share in 2030	96% (84% heat pump)	96% (84% heat pump)	41% (17% heat pump)
Electric share of installed residential HVAC systems in 2050	92% (75% heat pump)	92% (75% heat pump)	75% (54% heat pump)
New residential space heating heat pump COP in 2050	3.51	5	3.51
Residential and commercial electricity consumption from space and water heating in 2050	4.6 TWh	4.2 TWh	4.3 TWh

We have not examined a reference case which fails to achieve zero emissions by 2045 (in line with California's statewide net-zero goal). Because GHG reductions are required, the relevant

[xxvi] The Evolved Energy Research (EER) model assumptions are described in Appendix A Table 1.
[xxvii] Assumed to be a gas that reduces GHGs by 95 percent relative to fossil gas.

questions for policymakers and the public relate to which pathway to decarbonization to choose, not whether to decarbonize at all. Comparing the decarbonization cases to a “reference” or “business as usual” case that fails to reduce emissions would not provide useful insights.

Central Scenario (High Electrification) Results

This case illustrates a decarbonization pathway centered on switching space and water heating systems from natural gas (and delivered fuels) to electricity, predominantly heat pumps. Figure 5.12 shows the breakdown in sales for space and water heating in the residential and commercial markets.

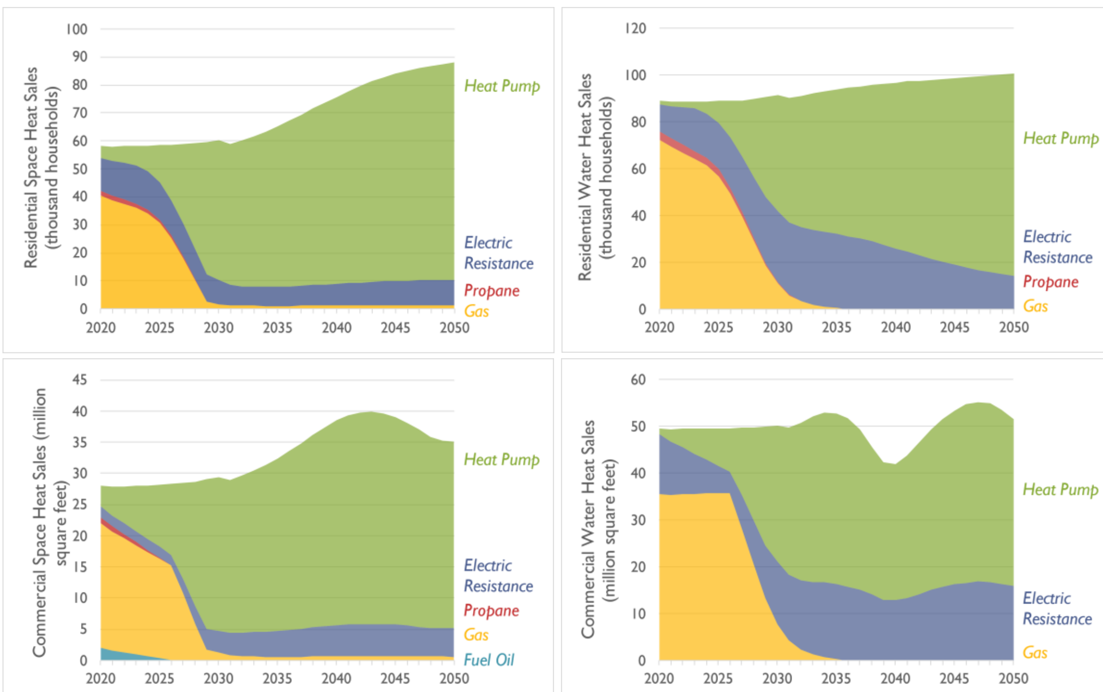


Figure 5.12. Sales of space and water heating equipment, by fuel and type, in the Central case.

Space heating systems are replaced at a slower rate than water heaters, so some gas space heating equipment remains in use in 2050, while gas water heating is effectively eliminated. Figure 5.13 shows the stock of space and water heating systems by fuel.[xxviii]

[xxviii] By “stock” we mean the total installed base of systems in buildings (not the equipment stocked for sale by distributors).

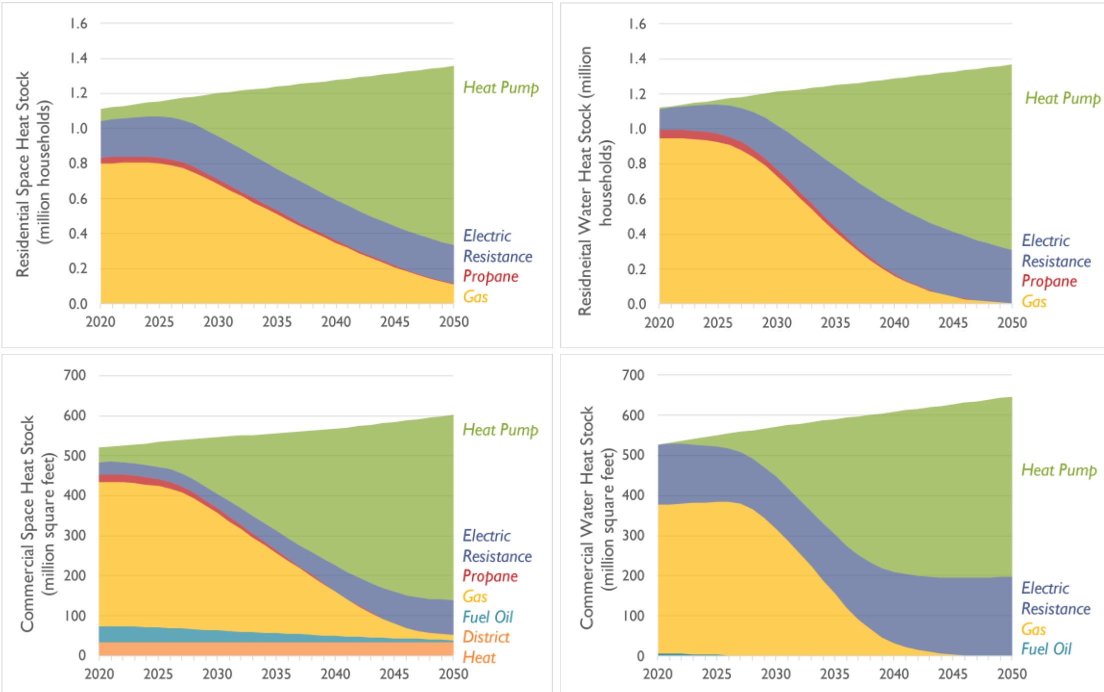


Figure 5.13. Stock of space and water heating systems, by fuel and type, in the Central case.

As building systems are electrified, the resulting on-site energy use and emissions change. Total site energy consumption falls, as shown in Figure 5.14, because electric heat pump technologies are much more efficient than combustion-based or resistive heating.

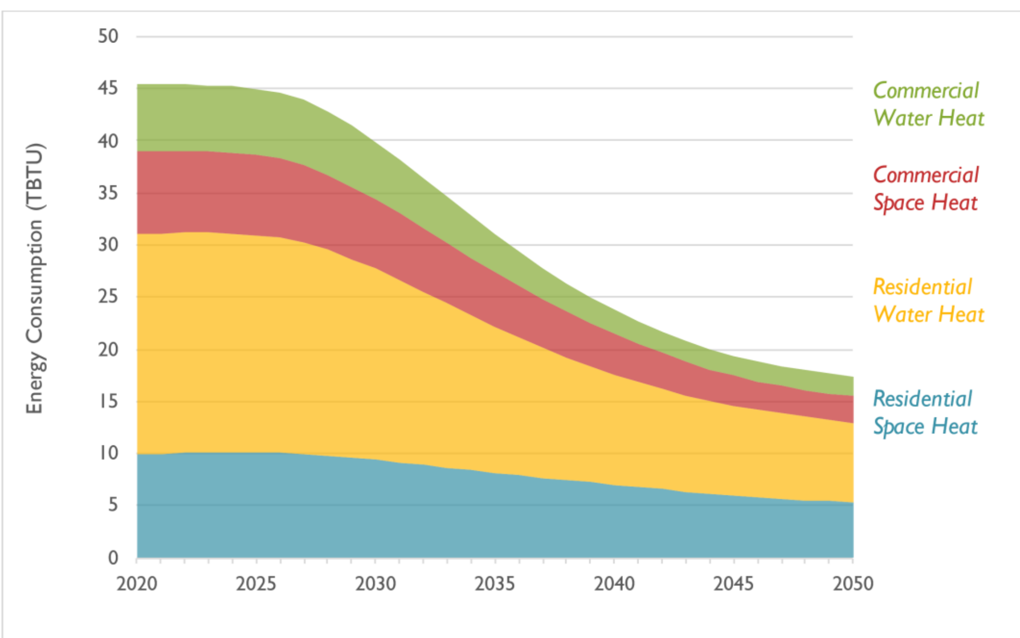


Figure 5.14. Total site energy consumption for space and water heating in the Central case.

Natural gas use would decline to about 3 percent of current levels, with remaining use primarily for residential space heating, as shown in Figure 5.15.

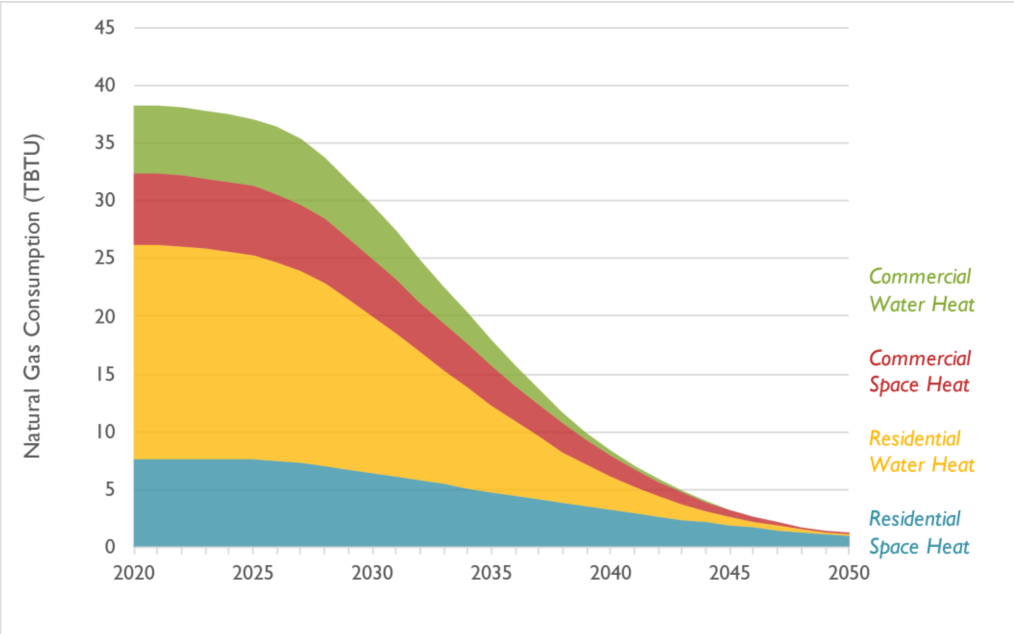


Figure 5.15. Use of natural gas for space and water heating in the Central case**.**

On-site GHG emissions, which are currently dominated by natural gas combustion, would follow a trajectory almost exactly aligned with the natural gas trajectory. Figure 5.16 shows the on-site emissions, by fuel. Remaining emissions in the natural gas sector could be reduced by using small amounts of low-carbon gas such as biomethane.

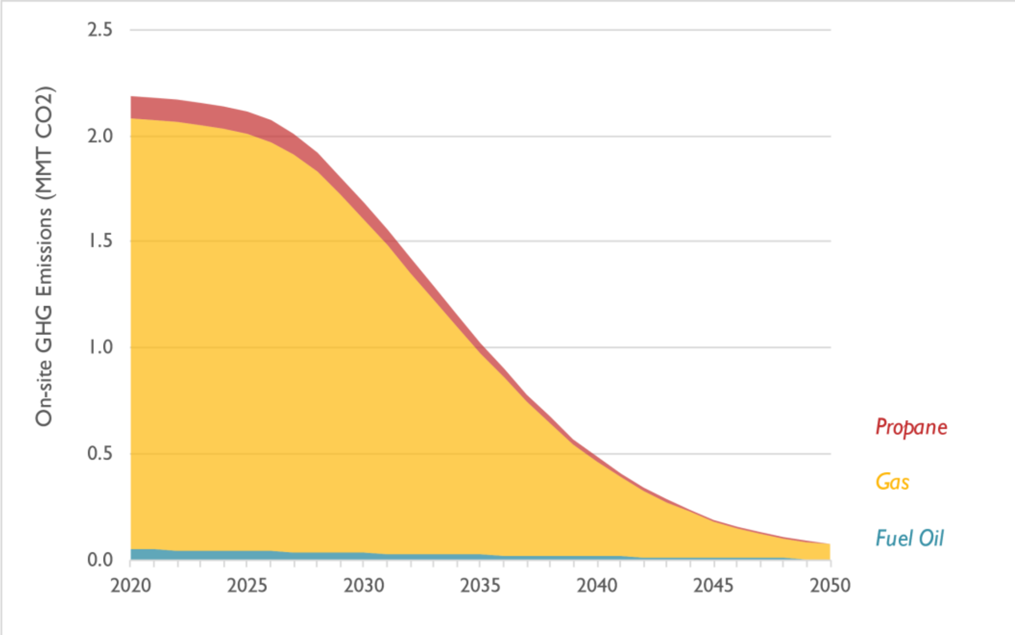


Figure 5.16. On-site GHG emissions from space and water heating, by fuel, in the Central scenario, without use of low-carbon gas.

Electricity use for space and water heating, however, would increase substantially, as shown in Figure 5.17. Electric sector GHG emissions are set to decline to zero by 2045 as a result of California state electricity policy.

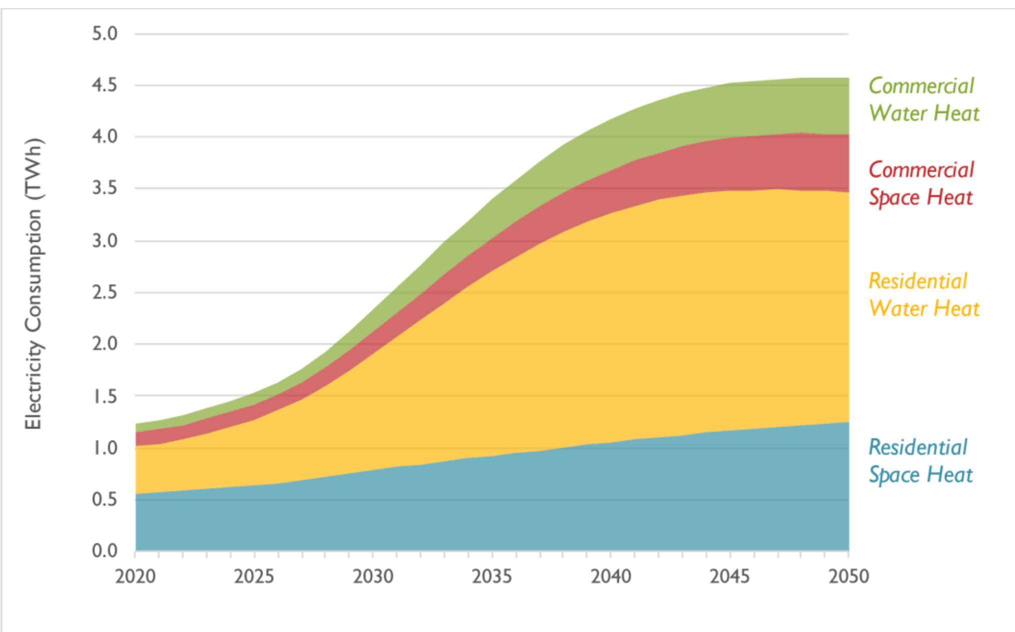


Figure 5.17. Consumption of electricity for space and water heating in the Central scenario.

While this analysis shows an increase of more than a factor of three in electricity use for space and water heating, the overall effect on SDG&E electric sales would be more muted. SDG&E's 2020 electric sales totaled a bit more than 14 TWh.[38] This is because electricity is used for many other purposes today, and those uses would continue. In addition, electric vehicles would drive an even greater increase in SDG&E's electric sales. Our analysis does not extend to an hourly look at load shapes from different end uses. However, the increase in electric consumption shown here does not appear likely to drive a substantial increase in SDG&E's peak electric demand. In 2020, SDG&E experienced a peak demand of about 4,600 MW, driven by summer air conditioning load, while its winter peak loads were less than 3,000 MW.[38] This indicates there is substantial headroom for winter heating load without driving new distribution system or transmission system peaks. To the extent that new water heating loads could add to the summer peak, rate design and control technologies can help to shift these loads to off-peak hours.

Low Demand Case Results

The primary difference between this case and the Central, or high-electrification, case is that the electric equipment that replaces combustion-based space and water heating equipment is more efficient. This case has minimal changes in the sales and stock of natural gas equipment. Figure 5.18 shows the electricity demand trajectory for space and water heating in this case, compared to the Central case.

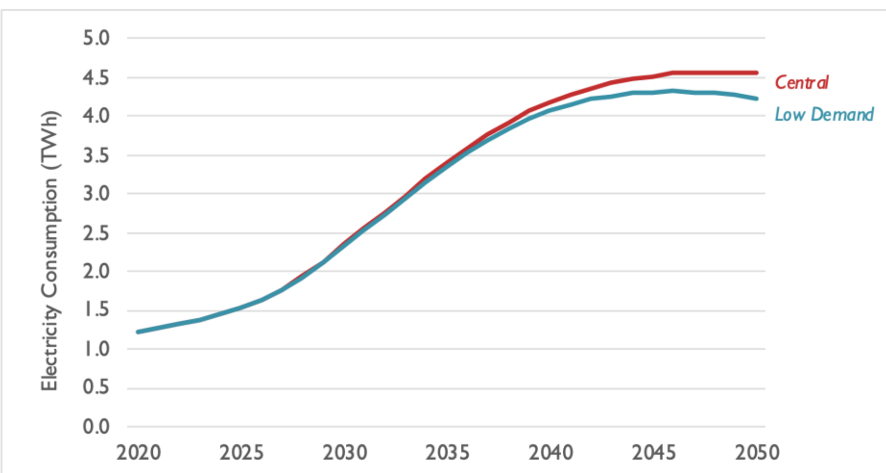


Figure 5.18. Electricity consumption for space and water heating in the Low Demand scenario and the Central scenario

The use of higher-efficiency equipment results in lower electric supply costs (see below) and a lower demand for the construction of zero-carbon electric generators. The electric consumption reduction in this case in 2050 relative to the Central case, about 330 GWh, is equivalent to avoiding the construction of about 124 MW of solar PV or 97 MW of onshore wind resources.

Partial Electrification Case Results

In the Partial Electrification case, market share for electric technologies is smaller, and increases later, than in the Central case. Figure 5.19 shows the heat pump market shares for residential and commercial space and water heating used for this case.

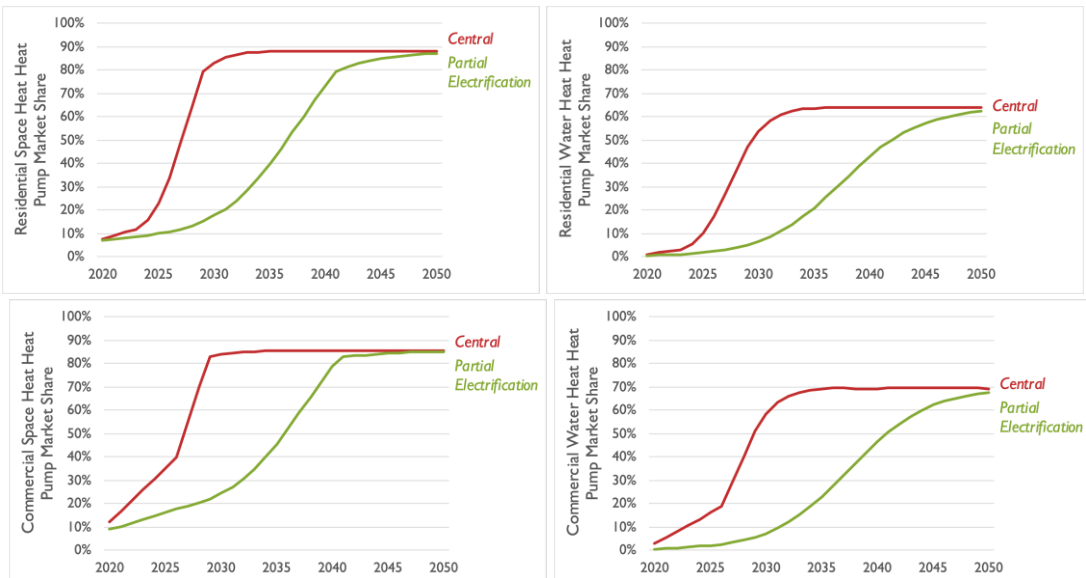


Figure 5.19. Heat pump market shares of new system sales in the Partial Electrification and Central scenarios.

As a result of this slower uptake of electric options, the stock of natural gas systems remains higher throughout the study period, as shown in Figure 5.20. (Compare with Figure 5.13 above.)

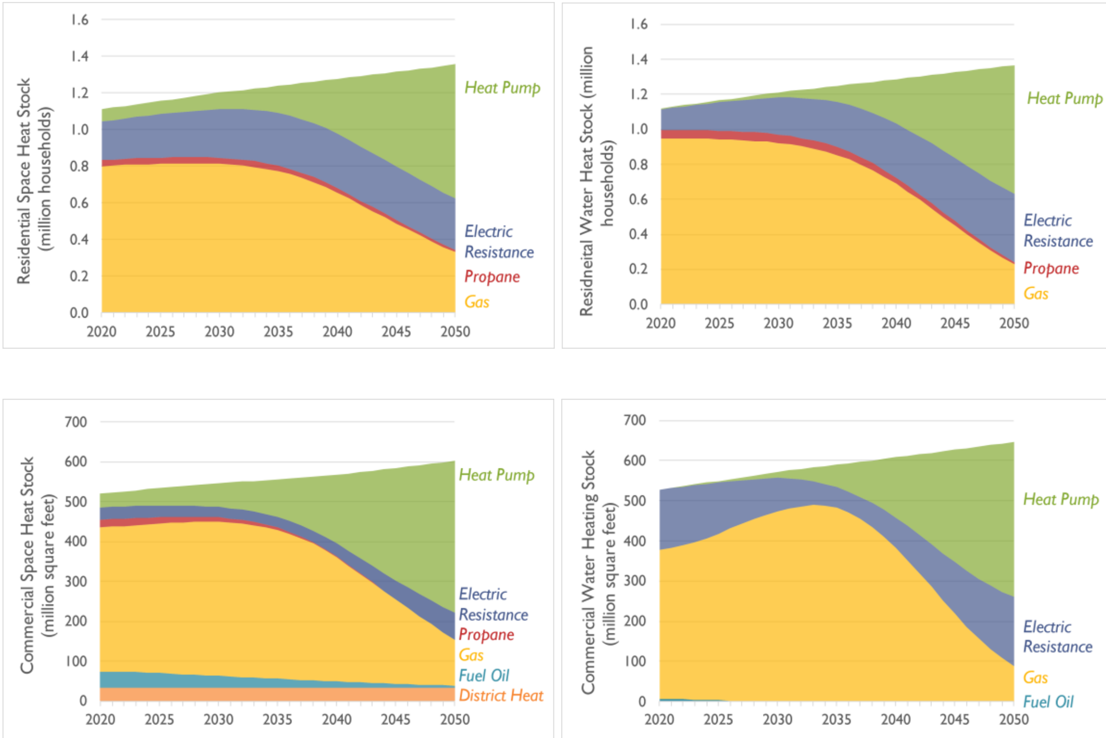


Figure 5.20. Space and water heating stock in the Partial Electrification scenario.

On-site pipeline gas use also remains higher through 2050, as shown in Figure 5.21.

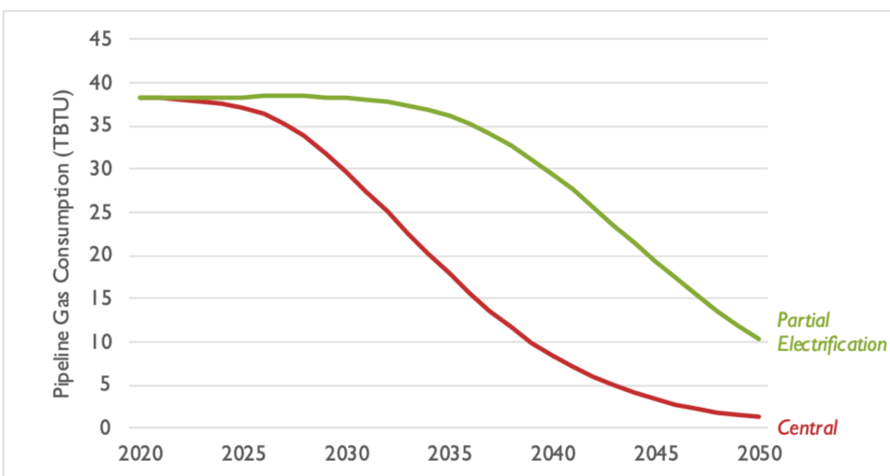


Figure 5.21. Pipeline gas consumption in the Partial Electrification and Central scenarios.

To represent potential scaling of low-carbon gaseous fuels in this case, we have increased the amount of biomethane and synthetic natural gas distributed using the pipeline gas system from zero in 2030 to 19.4 TBTU in 2045. This is enough to fully replace fossil gas in 2045 and later years. If we optimistically assume that this gas has emissions equal to 5 percent of fossil natural gas emissions, then the emissions trajectory for this case is as shown in Figure 5.22. For the purposes of cost estimation in the following section, we assumed that this low-carbon gas has an average cost of $30 per MMBTU.[xxix] This cost reflects the limited quantity of fuel required and thus the ability of biomethane to meet some or all of the demand.

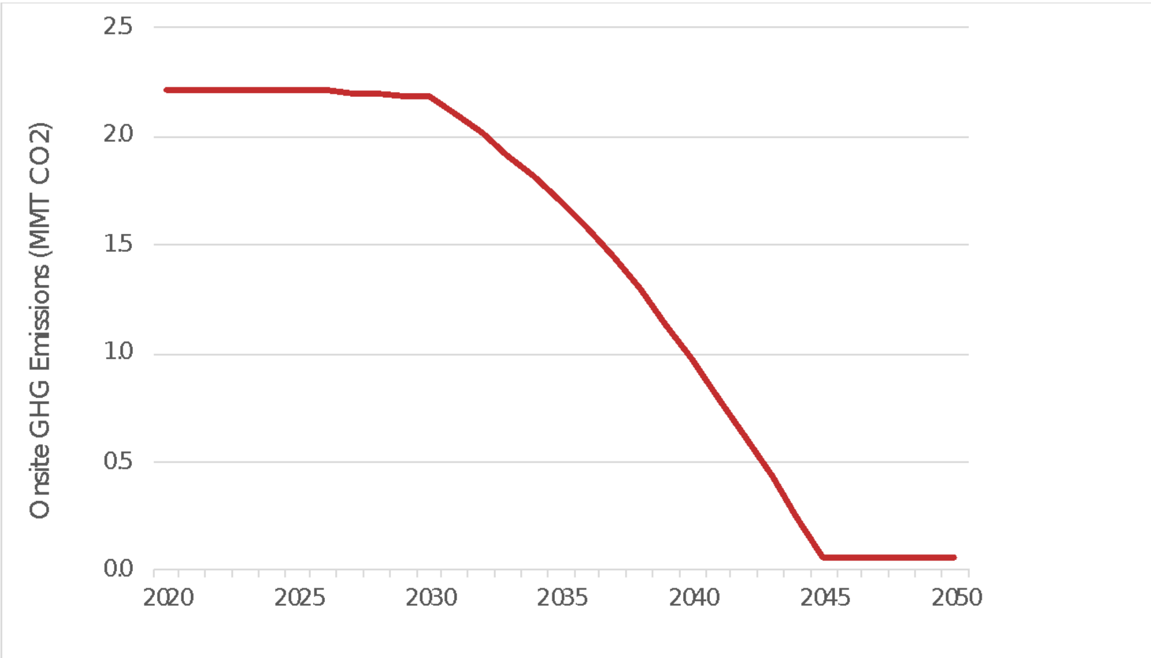


Figure 5.22. Onsite GHG emissions in the Partial Electrification scenario, reflecting increasing use of low-carbon fuels in place of pipeline gas starting in 2030.

Capital and Operating Costs

All the decarbonization scenarios considered here result in substantial changes in household and business spending on heating systems, water heaters, and the fuel and electricity to operate those systems. Heat pumps displace the need to pay for separate air conditioning and furnace systems. Heat pump water heaters are more expensive upfront than traditional electric resistance or gas storage water heaters.

Fuel and electricity costs are driven by the need to maintain the delivery infrastructure for each fuel, as well as the cost of low- to zero-carbon energy sources to reliably meet energy demands.

Table 5.7 shows the present value of estimated capital and operating costs between 2021 and 2050 for each case, using a 3 percent real discount rate. Interestingly, the three scenarios have

[xxix] We also assumed that fossil gas would have the cost for Henry Hub projected by the *Annual Energy Outlook 2021* published by the U.S. Energy Information Administration.

almost indistinguishable present value costs—well within the margin of error of the numerous cost assumptions that went into developing them. As expected, the Partial Electrification case has lower building system capital costs (because it depends on mature technologies), but fuel costs are higher as a result of the need for low-carbon gas fuel. If low carbon gas were to become available at scale and at costs well below $30 per MMBTU, this case would be distinctly less expensive than shown here. Similarly, if low carbon gases are not available or only available at scale at costs above $30/MMBTU, the high electrification cases would be less expensive. While the uncertainty is smaller, electricity costs could have a similar effect. This analysis uses long-term marginal electric supply costs from SDG&E's integrated resource plan (approximately 11 cents per additional kWh).[39]

The costs presented here are only the marginal costs associated with the electric and pipeline gas systems under a case in which those systems continue to be operated at the scale and with the same regulatory treatment as they are today. Therefore, these costs also do not reflect the potential to reduce gas system costs in the electrification cases, which are discussed in the following section. These costs are societal costs. How they are spread among customers is a matter of public policy, including incentives, weatherization and utility demand-side management programs, rate design, and tax policy.

Table 5.7. Present value capital and operating costs under three decarbonization scenarios (in billions of $2021).

	Central	**Low Demand**	**Partial Electrification**
Capital costs			
Res. space heating	$12.8	$12.8	$11.7
Res. water heating	$2.8	$2.8	$2.5
Comm. space heating	$7.3	$7.3	$7.0
Comm. water heating	$0.4	$0.4	$0.4
Electric upgrades	$0.6	$0.6	$0.4
Operating costs			
Electricity	$6.3	$6.1	$4.8
Pipeline gas	$2.0	$2.0	$5.2
Total	$32.2	$32.1	$32.0

5.4 Gas Utility and Rate Impacts

Introduction to Utility Finance and Economics

No matter what pathway is pursued, decarbonizing San Diego's buildings will transform the business of the county's gas utility, San Diego Gas and Electric (SDG&E). In any case, SDG&E will transport much less gas to homes and businesses than it does today. This section focuses on the economics and business model of the gas utility portion of SDG&E. SDG&E as an enterprise also has the ability to coordinate its electric utility planning with changes on the gas side.

SDG&E, like all investor-owned regulated utilities in the United States, is allowed to earn a rate of return based on the amount of capital that it has invested in the transmission and distribution assets that serve its customers. The utility's rates are designed to recover the company's "revenue requirement"–the amount of money it must collect from customers each year to pay for that year's depreciation of its assets, cover operating costs, and leave a just and reasonable return on invested capital for its bondholders and shareholders. Gas rates are composed of the delivery rate, which covers the cost of the local transmission and distribution systems, and the supply rate, which covers the cost of the commodity fuel that flows through the pipes. SDG&E does not make any profit on the supply rate – it simply passes fuel costs through as an operating expense.

Changes in how pipeline gas is used in San Diego County will cause a substantial change in how this business model functions. If the utility maintains its full gas system and invests in that system as it has historically done, while gas sales fall, it will need to raise the rates it charges per unit of gas in order to recover its full revenue requirement. If it doesn't raise rates sufficiently, its returns to investors will fall. However, as the gas utility raises rates, more customers may choose to use electricity instead of gas, to lower their energy bills. At the same time, greater utilization of the electric system, without creating new peak-related costs, would allow electric rates to decline. Combined, these rate effects would create an accelerating departure from the gas system, as continued electrification would accelerate the rate differential.

Delivery rate increases could be mitigated by retaining a larger amount of pipeline gas sales. However, for the County's GHG goals to be met in this case, the remaining fuel sales must be low-carbon fuel. This fuel is much more expensive than fossil natural gas. As a result, the supply portion of gas rates would increase substantially.

Low-income customers and tenants are particularly vulnerable to accelerating gas rate increases because these households have the least ability to invest in changes in their home's water and space heating systems to mitigate rate changes. The gas utility's transition path is also particularly important to the utility employees and contractors who install and maintain the gas pipeline infrastructure. Understanding the dynamics and timing of rate increases and gas customer economics is important to managing the equitable and just transition of the gas system into a decarbonized future.

Scenario Results without Mitigation

In order to investigate the impact of changes in gas sales and the number of gas customers as county residents and businesses decarbonize their buildings, we modeled SDG&E's gas utility revenue requirements (in total and per customer), rate base, and rates in both the Central and Partial Electrification cases. In both cases, we did not apply any of the mitigating actions that we detail below. In that way, these results present a bookend case, with higher rates and more assets at risk than would be experienced in reality. We have also not modeled the impact of electrification on electric rates and bills (which will also be strongly impacted by transportation electrification).

Because we assumed no mitigating actions, SDG&E's total revenue requirements (other than the cost of fuel) and rate base are not affected by the scenario. In both cases, we assume that SDG&E continues to add new customers through 2036 (albeit at a declining rate) and continues to replace aging assets at the same pace it does today. It maintains the full extent of its gas pipeline system. Figure 5.23 shows the resulting revenue requirement for the regulated gas delivery business (that is, not including the cost of fuel), while Figure 5.24 shows the utility's rate base. [xxx] In both cases, we have adjusted to real 2020 dollars, to subtract out the effect of underlying inflation.

[xxx] Rate base is the amount of unrecovered assets on which the utility earns its return for shareholders. It is generally equal to the undepreciated (remaining) value of the utility plant in service, adjusted by the tax treatment of depreciation.

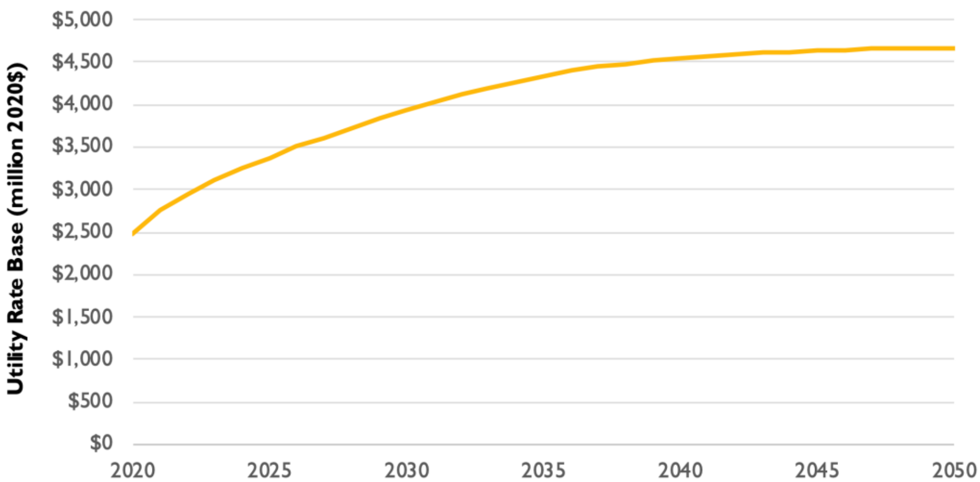


Figure 5.23. Gas utility revenue requirement for delivery services.

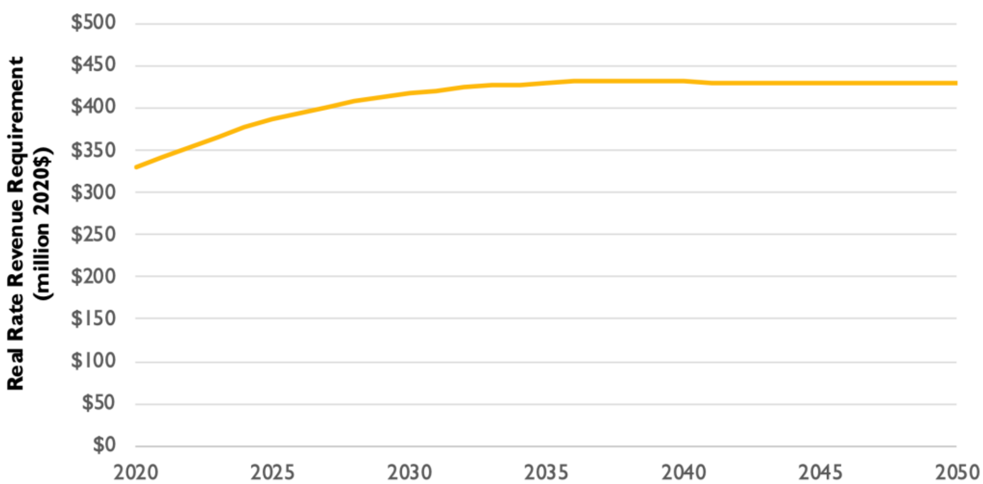


Figure 5.24. Gas utility rate base

Where the scenarios differ are in three further aspects: the cost of fuel, the number of customers, and the amount of fuel delivered. As shown in Figure 5.25, adding the cost of fuel to the delivery revenue requirement (dashed yellow line) results in the Partial Electrification (green) and High Electrification (red) trajectories.

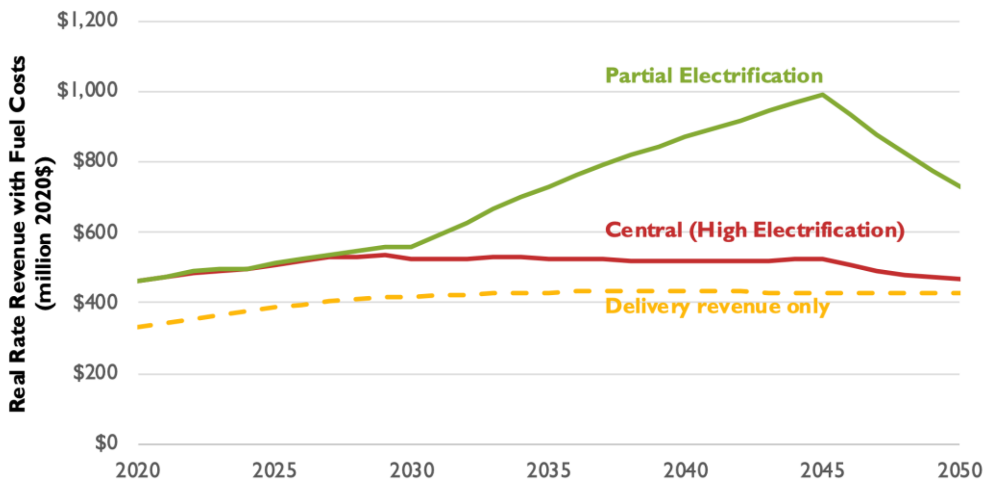


Figure 5.25. Gas utility revenue, including fuel costs.

To estimate the trajectory for delivered gas rates in each case, we divided the total revenue requirement by the total sales of pipeline gas in each case. This results in the forward rate curves shown in Figure 5.26. While the Partial Electrification case has lower rates than the Central case, even this case shows rates that far exceed today's average gas rates of just over $1 per therm. Both cases have rates that exceed $2 per therm by the 2030s (2033 in the Central case and 2038 in the Partial Electrification case). These higher per-unit rates could encourage customers to choose to heat with electricity, absent policy intervention to change the relative costs of fuels.[xxxi]

[xxxi] This analysis uses the total revenue requirement divided by total sales as a proxy for rate impacts. We do not distinguish between rate classes, and we do not distinguish between the monthly customer charge and the marginal rate for consumption, which each send different signals that shape customer behavior. Rate designs that shift more costs into the monthly customer charge would strengthen gas in marginal competition with electricity for each end use, while also giving customers a stronger incentive to fully disconnect from the gas network.

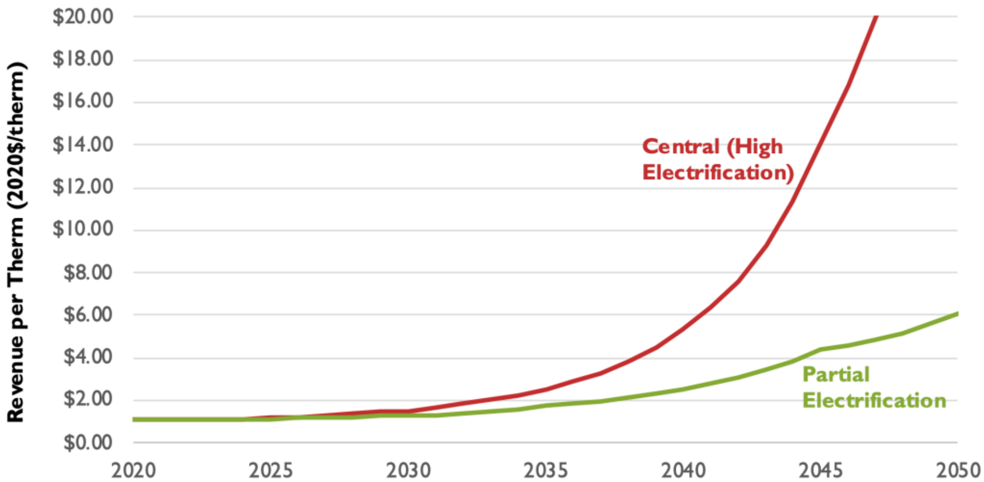


Figure 5.26. Forward gas rate curves for the Central (red) and Partial Electrification (green) scenarios.

Customers do not pay rates–they pay bills. Therefore, it is necessary to multiply the rates by the average consumption per customer to evaluate the impact of each scenario on the total annual energy costs of the customers who remain connected to the gas system. Figure 5.27 shows the resulting energy bills.

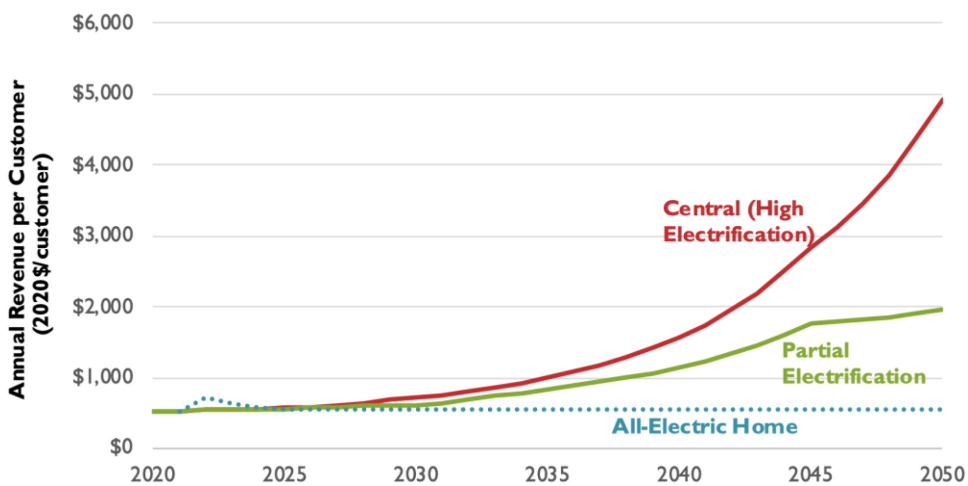


Figure 5.27. Average customer bills for gas customers in the Central (red) and Partial Electrification (green) scenarios, along with the per-customer increase in electric utility revenues from an all-electric home switching from gas (blue dashed).

These bills illustrate the challenge facing SDG&E and its stakeholders as it plans a path forward: in both cases the cost of gas service per customer increases substantially. While gas customer bills in the Partial Electrification scenario are lower than in the Central case, in both cases they rise to far exceed the bills for equivalent service provided with all electric appliances.[xxxii] Our analysis indicates that, absent policy intervention or mitigating actions, the Partial Electrification case is not a stable equilibrium.

Mitigation Approaches

SDG&E, its owners, and its regulators have numerous options to evolve the utility's practices and business model to mitigate the rate trajectories that would result from decarbonization. The objectives of these approaches would be to more equitably share the cost of the existing gas system between today's customers and future customers, as well as to limit the risk to residents and investors that the utility will leave substantial stranded assets. Stranded assets are investments that the utility made but which are retired before their full asset value has been recovered.

The cost of stranded assets could be passed to utility investors, which would risk the financial viability of the company. This is not optimal because San Diego residents require SDG&E to be a viable enterprise to continue to provide electric service, at least, and if financial viability were threatened while there were still gas customers their service would also be at risk. Safety of the electric and gas systems could be at risk in such a case. The value of some stranded assets could instead be recovered from electric ratepayers or from taxpayers. Both approaches would require changes in fundamental approaches to utility ratemaking. One option would be securitization, wherein stranded assets are bought out by a public bond-backed entity with a lower cost of capital (thus lowering the total funds to be recovered), and then the bond is paid back over an appropriate timeframe using electric ratepayer funds or tax revenues. California is using securitization to address electric utility costs associated with wildfire risk reduction.[xxxiii]

In order to limit the amount of stranded assets whose fate must be resolved in groundbreaking or painful ways, utility financial and infrastructure practices could be changed in the near term.[xxxiv] These approaches would have different effects on the utility's annual revenue requirements. In some cases, stranded cost risks are mitigated by recovering funds sooner,

[xxxii] The exact customer economics depend on rate design for both gas and electric utilities. Figure 28 reflects the relevant per-customer costs of service (accounting for the fact that building electrification will not drive changes in electric transmission and distribution costs), as a proxy for the costs that would be assigned to each customer under a reasonable rate design.

[xxxiii] See, for detail, California Assembly Bill 1054 (passed 2019) and California Public Utilities Code, Sec. 8386.3.

[xxxiv] One resource to learn more about the options discussed here, and others, is *Managing the Transition: Proactive Solutions for Stranded Gas Asset Risk in California* by Bilich, Colvin, and O'Connor (2019) for the Environmental Defense Fund (available at https://www.edf.org/sites/default/files/documents/Managing_the_Transition_new.pdf.) While the analysis in this report differs somewhat from that study, the general conclusions and analysis are compatible.

while there is still extensive use of the gas system. In other cases, actions mitigate risks by reducing the size of the total investment at risk. Some actions do not change the total size of the investment or stranded cost risk, but can mitigate rate impacts and thereby buy breathing room to use rates to recover invested capital. In each case below, we change one aspect of the utility's action or accounting, in order to illustrate the impact of each change. In reality, the utility's management, along with its investors, regulators, and other stakeholders, would develop a portfolio of actions to best achieve their objectives.

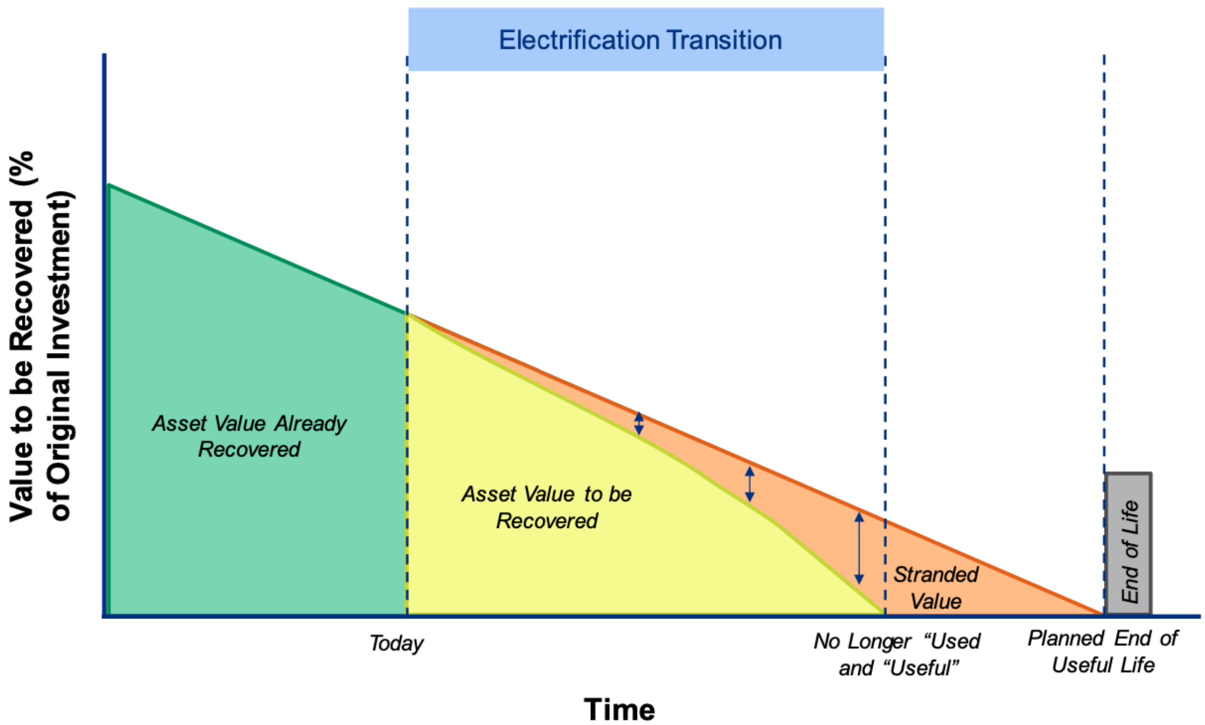


Figure 5.28. Illustration of the amount of stranded asset risk when an asset is no longer used and useful, before the end of its planned lifetime. Source: Bilich, Colvin, and O'Connor, 2019. "Managing the Transition: Proactive Solutions for Stranded Gas Asset Risk in California." Environmental Defense Fund. Reproduced with permission.

Accelerated depreciation

Gas utility assets are generally depreciated over their expected engineering lifetime—as many as 70 years for new plastic pipes, for example. However, for intergenerational fairness, this approach assumes that the pipes will carry roughly the same amount of gas each year throughout their lifetimes. As the gas sales trajectories shown in this chapter illustrate, this assumption no longer holds. Accelerating the recovery of the invested capital in the gas system (e.g., so that it would fully recover by 2045) would reduce stranded cost risk, at the cost of higher gas rates in the near term. Regardless of the treatment of depreciation, long-term gas rates would still rise with falling sales, as long as operations and maintenance (O&M) costs of the system remain roughly constant (in inflation-adjusted terms).

Figure 5.29 shows the approximate rate trajectory for SDG&E under an accelerated depreciation scenario, compared with the traditional depreciation approach. This scenario was developed by setting the minimum depreciation rate for any asset type to 4 percent (equivalent to a 25-year depreciation period if there were no removal cost). Revenue requirements, and therefore rates, are higher in the near term with accelerated depreciation, as expected.

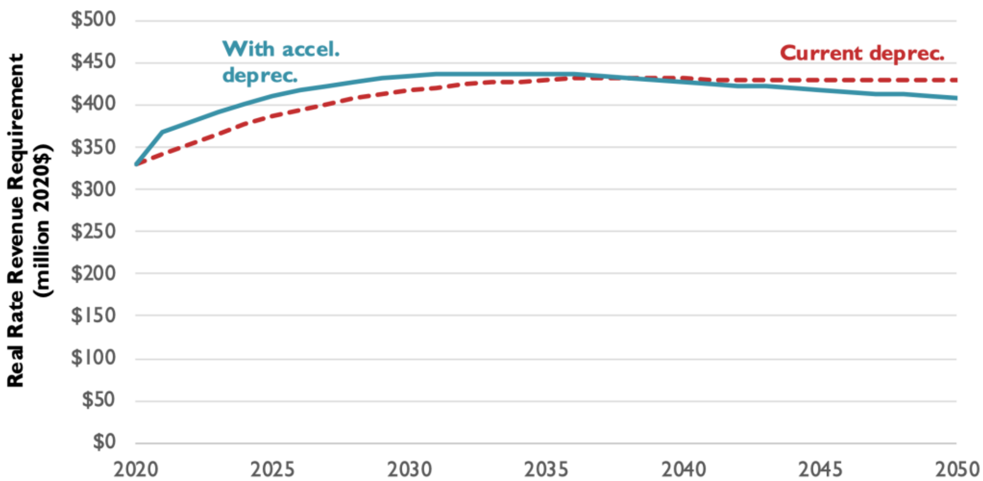


Figure 5.29. Gas utility revenue requirement with and without accelerated depreciation.

Figure 5.30 shows SDG&E's projected rate base in the Central case with and without accelerated depreciation. Rate base rises and then falls in the accelerated depreciation case, as the utility continues to make its historical pattern of capital investments. (Recall that this analysis changes only one aspect of utility behavior at a time.) However, the value of rate base at risk in the gas utility transition is reduced substantially—by more than $1.4 billion in 2050.

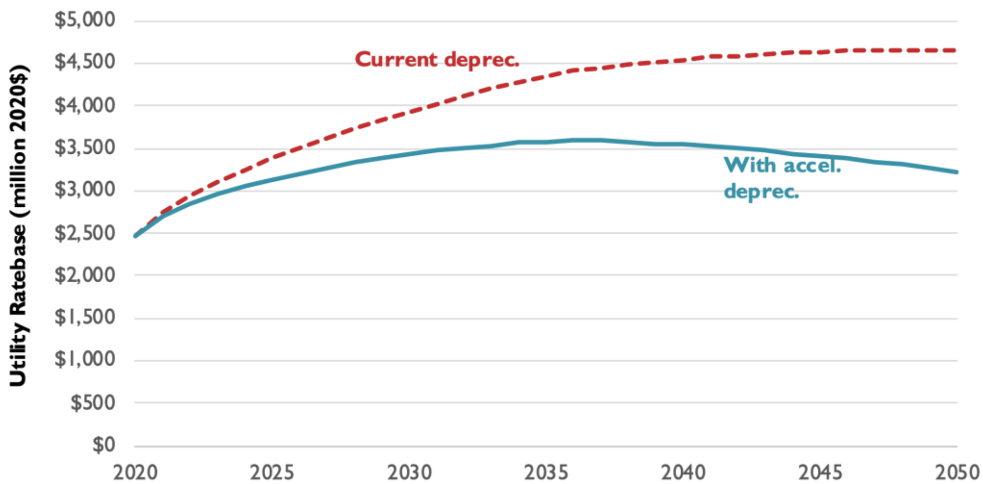


Figure 5.30. Gas utility rate base with and without accelerated depreciation

One minor, but impactful, change to depreciation practice could be the elimination of recovery of funds to remove gas assets upon their retirement. Standard depreciation practice recovers not just the amount invested in the pipe, but also the net cost of removal of the pipe at end of life. Because this action is expected to occur far in the future (when inflation will have raised the cost of removal), the removal cost can approach, or even exceed, the value of the asset itself. As a result, depreciation costs can be almost twice as large as they would otherwise be. If policymakers were to decide that gas pipes could be retired and abandoned in place, without removal, regulatory financial calculations could adjust, lowering gas rate pressures and creating room for accelerated depreciation or other approaches.

Limiting capital investment

Another approach to limiting stranded cost risk is to limit the amount of assets the utility has invested. Because past investments have already been made, the point of impact here has to do with the rate of new asset investment. SDG&E has been investing in assets for two primary purposes: (1) to extend pipes to serve new customers and (2) to replace old or damaged assets. Addressing these two drivers would require policy changes tailored to each.

Investment in pipes to reach new customers would be shaped by whether new customers demand gas service. If new construction is all electric, there would be no such investment. Other approaches, such as requiring customers that require a line extension to cover the full cost themselves, could also limit shareholder and other shared risk from these assets. Figure 5.31 shows the impact of eliminating gas line investments to reach new customers on the baseline trajectory of SDG&E's rate base. The utility's rate base is about $400 million smaller in 2050 without these additions.

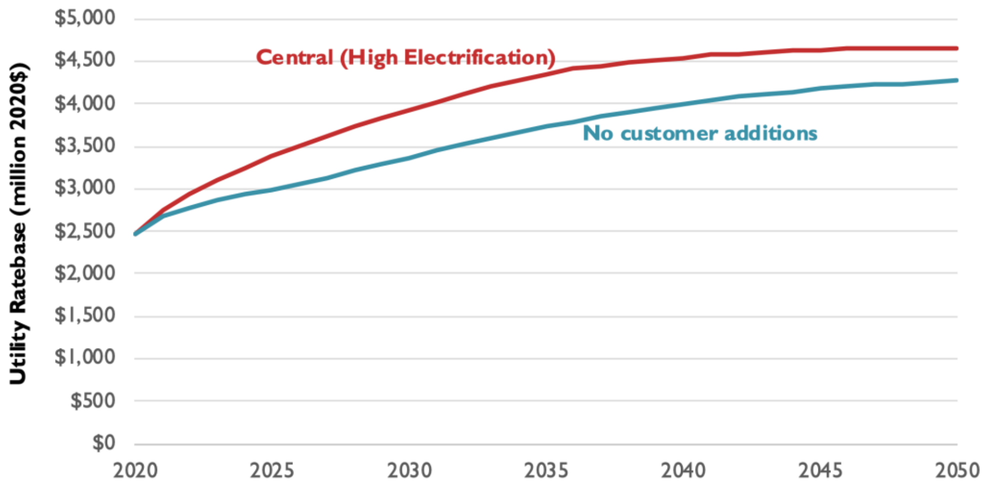


Figure 5.31. Gas utility rate base with and without new customer additions.

Most of SDG&E's capital investments relate to replacing old assets with equivalent new ones. These replacements occur because of actual leaks or damage to pipes, as well as on a proactive basis, and are justified on the basis of pipeline safety and leak reduction. We have not assessed the necessity of SDG&E's pipeline replacements. However, in order to indicate the potential ratepayer impact of slowing the pace of these replacements (which could correspond to targeting replacement only to the most urgent locations), we modeled a reduction in the pace of these replacements by a factor of three. The results are shown in Figure 5.32. This figure also shows the combined effect of eliminating new gas lines and reducing investment in existing asset replacement by a factor of three. Together, these changes would reduce the utility's rate base at risk in 2050 by $1.15 billion.

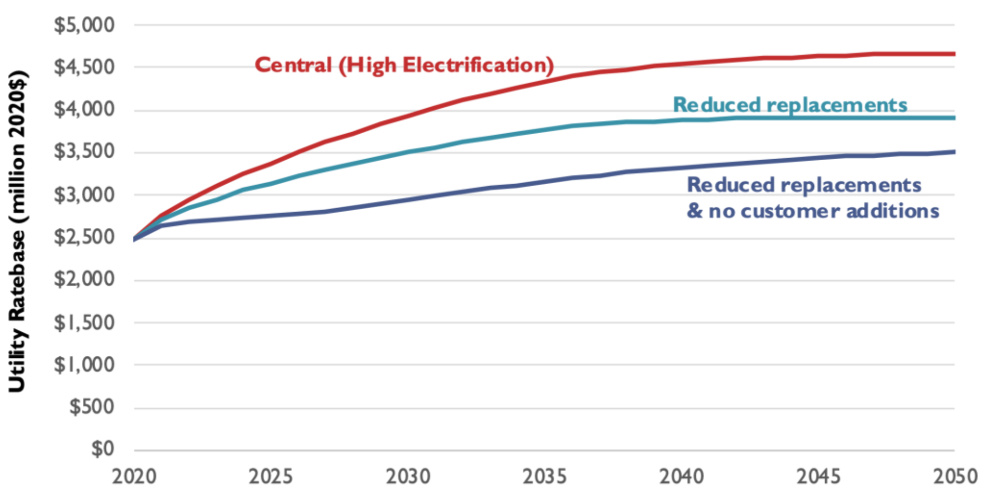


Figure 5.32. Gas utility rate base with reduced pipeline and service replacement rate, and combined with no new customer additions.

Targeted system retirements

One way to reduce the need for new capital investment, while also reducing O&M costs, would be to retire gas system assets instead of replacing them. Figure 5.33 shows an illustration of this. By targeting electrification to buildings served by a particular gas system asset, that asset can then be retired. Targeted retirement is likely to be a more cost-effective way to manage the gas transition than replacing assets, in the face of declining sales.

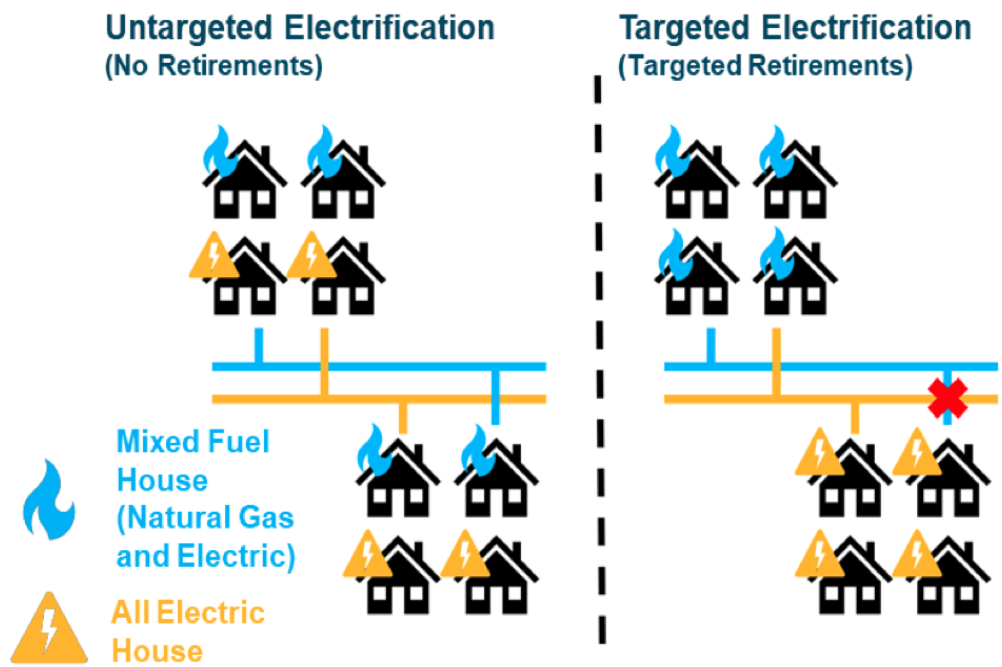


Figure 5.33. Illustration of the gas infrastructure implications of targeted vs. untargeted electrification. Source: Asa et al., 2020. "The Challenge of Retail Gas in California's Low-Carbon Future: Technology Options, Customer Costs, and Public Health Benefits of Reducing Natural Gas Use." E3 for the California Energy Commission.

One challenge with this approach is that the pace of natural system replacements in San Diego is much slower than the pace at which the system might be abandoned, particularly under a high electrification decarbonization pathway. SDG&E is currently replacing an average of about 33 miles of distribution main pipe per year. We estimate that SDG&E is also replacing about 1,400 service lines each year.[xxxv] If the customers served by these mains and services were electrified, rather than the pipes replaced, it would lower the utility's stranded cost risk by reducing its new investments.

While targeting electrification to the areas of pipe replacement would reduce stranded cost risk by limiting new capital investment, it does not eliminate the issue. Targeted electrification and

[xxxv] Services are the small pipes that connect customers to the mains.

pipeline retirement should also allow O&M costs to be reduced (since there are fewer miles of pipe to maintain), which could allow for either a stronger competitive position vs. electricity (thus allowing departures and sales reductions to be more measured and planned) or for more room in gas rates to recover asset value that would otherwise be stranded.

Figure 5.34 illustrates the impact on the utility's revenue requirements for gas distribution service (not fuel supply) in the Central case if mains replacement were replaced with targeted electrification, and customers due for new service lines were electrified instead. (As modeled, both transitions in utility practice would ramp in over the next decade.) In this example, we have also modeled no new customer additions. In this case the utility's rate base in 2050 would be about $1.4 billion less than in the unmitigated case. Further, targeting of electrification, which would involve retiring distribution mains not due for replacement, would create stranded costs that would need to be addressed in some fashion.

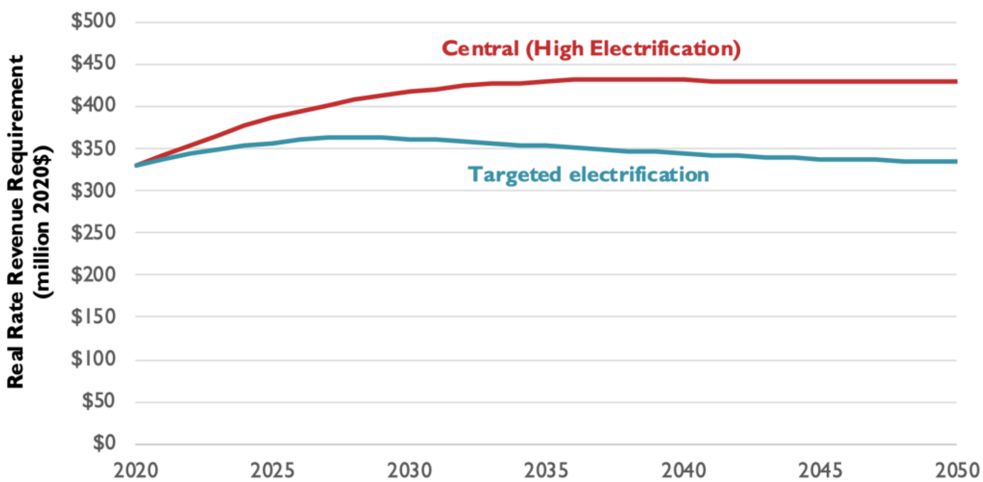


Figure 5.34. Gas utility delivery revenue requirement (without fuel costs) in the Central case, compared with a case where electrification is targeted to allow the utility to avoid rebuilding aging distribution mains.

Key Actions

- To put San Diego's buildings on a course for decarbonization by mid-century, it is important to take action beginning immediately. This timeframe is driven by the long lifetime of building components such as HVAC systems and water heaters, along with the relatively nascent state of the market for efficient low-carbon technologies that can reduce direct emissions from the region's buildings. While the end state for the region's buildings is not known, the initial steps are common across all pathways. These include:
- Increasing adoption of efficient heat pump-based space and water heating systems in both new and existing buildings, with particular focus on assistance for low-income residents and rental buildings;

- Researching and piloting production and use of low-carbon gaseous fuels that can be used for hard-to-electrify end uses; and
- Mitigating stranded cost risk by minimizing unnecessary extensions or replacements of the gas pipeline system and by accelerating depreciation of existing utility assets.

Works Cited

1. U.S. Census Bureau. 2021. County Population Totals: 2010-2019. https://www.census.gov/data/tables/time-series/demo/popest/2010s-counties-total.html#par_textimage_242301767.
2. U.S. Census Bureau. 2021. 2019 County Business Patterns. Available at: https://www.census.gov/programs-surveys/cbp.html. Synapse review of property data provided by San Diego County Assessor's Office
3. The City of San Diego. 2007. San Diego Modernism Historic Context Statement. Available at: https://www.sandiego.gov/sites/default/files/modernism_2007.pdf.
4. Sutro, Dirk. 2002. San Diego Architecture from Mission to Modern: Guide to the Buildings, Planning, People, and Spaces That Shape the Region. American Institute of Architects | San Diego. Sunbelt Publications.
5. University of San Diego. 2021. Indian Reservations in San Diego County. Available at: https://www.sandiego.edu/native-american/reservations.php
6. U.S. Census Bureau. 2021. 2020 Census - Census Tract Reference Map. Available at: https://www.census.gov/geographies/reference-maps/2020/geo/2020pl-maps/2020-census-tract.html.
7. DATA.GOV. 2021. Military Installations, Ranges, and Training Areas. Available at: https://catalog.data.gov/dataset/military-installations-ranges-and-training-areas.
8. County of San Diego. 2018. Greenhouse Gas Emissions Inventory, Projections, and Reduction Targets. Available at: https://www.sandiegocounty.gov/content/dam/sdc/pds/advance/cap/publicreviewdocuments/CAPfilespublicreview/Chapter%202%20Greenhouse%20Gas%20Emissions%20Inventory%2C%20Projections%20and%20Reduction%20Target.pdf.
9. DNV GL Energy Insights. 2021. 2019 California Residential Appliance Saturation Study (RASS). Available at: https://www.energy.ca.gov/data-reports/surveys/2019-residential-appliance-saturation-study.
10. City of San Diego. Building Energy Benchmarking. Accessed September 23, 2021. https://www.sandiego.gov/sustainability/energy-and-water-efficiency/benchmark.
11. City of San Diego. Building Energy Benchmarking. Accessed September 23, 2021. https://www.sandiego.gov/sustainability/energy-and-water-efficiency/benchmark.
12. U.S. Energy Information Administration (EIA). 2013. Commercial Buildings Energy Consumption Survey (CBECS), 2012. Available at: https://www.eia.gov/consumption/commercial/data/2012/. EIA Form 176, Years 2005–2019; Form 861 and 861S, Years 2005–2019 and Year 2020 early release.
13. Mahone, A., et al. 2018. Deep Decarbonization in a High Renewables Future. Prepared by Energy and Environmental Economics for the California Energy Commission. Available at: https://www.energy.ca.gov/publications/2018/deep-decarbonization-high-renewables-future-updated-results-california-pathways.
14. Itron, Inc. 2014. California Commercial Saturation Survey Report. Prepared for California Public Utilities Commission. Available at: http://capabilities.itron.com/wo024/Docs/California%20Commercial%20Saturation%20Study_Report_Final.pdf.
15. Armstrong, S., et al. 2019. A Zero Emissions All-Electric Multifamily Construction Guide. Redwood Energy. Available at: https://fossilfreebuildings.org/ElectricMFGuide.pdf.
16. Mitsubishi . n.d., City Multi Brochure (CM11WD-I), p. 83, Available at: https://www.mitsubishielectric.com.au/assets/LEG/MEE10K026_CM11WD_I_w.pdf.
17. Northeast Energy Efficiency Partnership (NEEP). 2019. Variable Refrigerant Flow (VRF) Market Strategies Report. Available at: https://neep.org/sites/default/files/resources/NEEP_VRF%20Market%20Strategies%20Report_final5.pdf.

18. Bonneville Power Administration. 2018. HVAC Technology Guide. Page 106. Available at: https://www.bpa.gov/EE/Utility/Momentum-Savings/Documents/2018_BPA_HVAC_Technology_Guide.pdf.
19. Stagner, J.C. n.d. Stanford University's "fourthgeneration" district energy system. Available at: https://sustainable.stanford.edu/sites/default/files/IDEA_Stagner_Stanford_fourth_Gen_DistrictEnergy.pdf.
20. Northwest Energy Efficiency Alliance. 2014. Final Summary Report for the Ductless Heat Pump Impact and Process Evaluation. Available at: https://neea.org/resources/final-summary-report-for-the-ductless-heat-pump-impact-and-process-evaluation; Cadmus. 2016, Ductless Mini-Split Heat Pump Impact Evaluation. Available at: http://www.ripuc.ri.gov/eventsactions/docket/4755-TRM-DMSHP%20Evaluation%20Report%2012-30-2016.pdf
21. Schoenbauer, B. 2018. "Cold-Climate Air-Source Heat Pumps." Center for Energy and Environment. Available at: http://www.duluthenergydesign.com/Content/Documents/GeneralInfo/PresentationMaterials/2018/Day1/ccASHPs.pdf.
22. Mahone, A. et al. 2019. Residential Building Electrification in California - Consumer economics, greenhouse gases and grid impacts. Energy and Environmental Economics. Available at: https://www.ethree.com/wp-content/uploads/2019/04/E3_Residential_Building_Electrification_in_California_April_2019.pdf.
23. Air Conditioning, Heating, and Refrigeration Institute. 2021. Directory of Certified Product Performance. Available at: https://www.ahridirectory.org/Search/SearchHome.
24. Mai, T. T. et al. 2018. Electrification Futures Study: Scenarios of electric technology adoption and power consumption for the United States. National Renewable Energy Laboratory. Available at: https://www.nrel.gov/docs/fy18osti/71500.pdf.
25. E3. 2019. Residential Building Electrification in California - Consumer economics, greenhouse gases and grid impacts. Available at: https://www.ethree.com/wp-content/uploads/2019/04/E3_Residential_Building_Electrification_in_California_April_2019.pdf.
26. Jones, Betony. 2021. Los Angles Building Decarbonization: Community Concerns, Employment Impacts, Opportunities. Inclusive Economics.
27. U.S. EPA. 2021. "ENERGY STAR Certified Water Heaters." Available at: https://www.energystar.gov/productfinder/product/certified-water-heaters/
28. Delforge, Pierre and Swanson C. 2016. "Very Cool: Heat Pump Water Heaters Save Energy and Money." NRDC. Accessed September 27, 2021. Available at: https://www.nrdc.org/experts/pierre-delforge/very-cool-heat-pump-water-heaters-save-energy-and-money; Hopkins, Asa S., et al. 2018. Decarbonization of Heating Energy Use in California Buildings – Technology, Markets, Impacts, and Policy Solutions, page 21. Available at: https://www.synapse-energy.com/sites/default/files/Decarbonization-Heating-CA-Buildings-17-092-1.pdf.
29. Armstrong, S., et al. 2019; Bruce Sullivan. 2017. "CO2 Takes Heat Pump Water Heaters to the Next Level." Accessed September 27, 2021. Available at: https://zeroenergyproject.org/2017/05/22/co2-takes-heat-pump-water-heaters-next-level/; Steven Groves. 2018. "Mitigating the Parasitic Effect of Heat Pump Water Heaters on Home Heating Systems in Cold Climates" Fortis BC. Presentation at the 2018 ACEEE Hot Water Forum, March 21, 2018.
30. Carew, Nick. Et al. 2018. Heat Pump Water Heater Electric Load Shifting: A Modeling Study. Ecotope, Inc. Available at: https://ecotope-publications-database.ecotope.com/2018_001_HPWHLoadShiftingModelingStudy.pdf.
31. Ecotope. 2015. RCC Pilot Project: Multifamily Heat Pump Water Heaters in Below Grade Parking Garages in the Pacific Northwest.
32. Alan Meier et al. 2018. University of California Strategies for Decarbonization: Replacing Natural Gas, p. 76. Available at http://dms.hvacpartners.com/docs/1001/Public/0A/04-581025-01.pdf.

33. Gartman, M., S. Armstrong. 2020. "Heat Pumps for Hot Water: Installed Costs in New Homes". Rocky Mountain Institute and Redwood Energy. Available at: https://rmi.org/insight/heat-pump-hot-water-cost/; Jones, B.. 2021. Los Angles Building Decarbonization: Community Concerns, Employment Impacts, Opportunities. Inclusive Economics. Available at: https://drive.google.com/file/d/117bFbCLccCdu316IJAIHkRyoLMhQTQd3/view.
34. U.S. Energy Information Administration. 2015. "Table HC3.8 Appliances in homes in the South and West regions, 2015" Residential Energy Consumption Survey (RECS). Available at: https://www.eia.gov/consumption/residential/data/2015/hc/php/hc3.8.php
35. IEA Bioenergy. 2017. Methane emissions from Biogas Plants. Available at: https://task37.ieabioenergy.com/files/daten-redaktion/download/Technical%20Brochures/IEABioenergy_Task%2037_methane_emissions_2Psummary.pdf.
36. E3, 2018. Deep Decarbonization in a High Renewables Future: Updated Results from the California PATHWAYS Model. Prepared for the California Energy Commission. Available at https://www.energy.ca.gov/publications/2018/deep-decarbonization-high-renewables-future-updated-results-california-pathways
37. E3. 2021. Maryland Building Decarbonization Study Final Report. Available at: https://mde.maryland.gov/programs/Air/ClimateChange/MCCC/Documents/MWG_Buildings%20Ad%20Hoc%20Group/Maryland%20Buildings%20Analysis%20Slide%20Report.pdf.
38. San Diego Gas & Electric Company. FERC FINANCIAL REPORT FERC FORM No. 1: Annual Report of Major Electric Utilities, Licensees and Others and Supplemental Form 3-Q: Quarterly Financial Report for end of 2020/Q4.
39. San Diego Gas & Electric. 2020. Attachment A to the 2020 Integrated Resource Plan. https://www.sdge.com/sites/default/files/regulatory/Attachment%20A_Cost%20Table%20%281%29_0.pdf

6. Employment Impacts through Decarbonization for the San Diego Region

Robert Pollin, Department of Economics and Political Economy Research Institute (PERI), University of Massachusetts Amherst
Jeannette Wicks-Lim, PERI, University of Massachusetts Amherst
Shouvik Chakraborty, PERI, University of Massachusetts Amherst
Gregor Semieniuk, PERI, University of Massachusetts Amherst

Key Takeaways

- Between 2021 – 2030, the regional decarbonization pathway would generate an average of nearly 27,000 jobs per year in the San Diego region.
- Even taking into account the contraction of fossil fuel jobs, we estimate that no workers in the region's fossil fuel-based industries will have to experience job displacement before 2030.
- San Diego county and local governments should begin now to develop a viable set of just transition policies for the workers in the community who will experience job displacement between 2031 – 2050.
- The costs of a just transition will be much lower if the transition is able to proceed steadily rather than through a series of episodes. Under a steady transition, the proportion of workers who will retire voluntarily in any given year will be predictable, the transition process avoids having to provide support for a much larger share of workers.
- Geothermal production of the five sites identified in Imperial County would generate 1,900 jobs per year over a 10-year period.

In this chapter, we estimate the employment impacts of advancing the clean energy decarbonization program developed for the San Diego region by Evolved Energy Research, summarized in Appendix A. The Evolved Energy Research (ERR) model includes seven different energy system transformation scenarios between 2020 – 2050. The purpose of all of these scenarios is to present pathways through which CO_2 emissions in the San Diego region can fall to zero by 2050. In this chapter, we focus on what EER terms their "central case." They explain that this is the case through which the San Diego region can achieve zero CO_2 emission in 2050 at the lowest net cost. We focus in this chapter on the employment impacts between 2021 –

2030 through advancing the ERR central case in San Diego County.[xxxvi] We focus here on the 2021-2030 time period in order to inform future analysis on workforce development strategies for San Diego, modeled after California's Jobs and Climate Action Plan for 2030.[xxxvii] We do also report overall average annual job creation figures for the full 2020 - 2050 time period encompassed by ERR.

We also estimate in this chapter the impacts on employment of phasing down fossil fuel-based economic activity in the county. Within the ERR central case model, the phasing down of fossil fuel-based activity will be modest between 2021 – 2030, the decade of activity on which we focus here. As described in Appendix A, the model ERR assumes that natural gas consumption in the county will remain at its current level through 2030, while the consumption of oil will have fallen by 20 percent as of 2030 relative to current consumption levels. There is, at present, already close-to-zero coal consumption in the San Diego region.

This chapter will first focus on the employment creation impacts between 2021 - 2030 of the San Diego region advancing its zero-emissions program. We then turn to consider the employment impacts of phasing down fossil fuels in the region over this same period. [xxxviii]

Our overall findings can be summarized briefly. We estimate that, between 2021 – 2030, the regional decarbonization pathway would generate an average of nearly 27,000 jobs per year in the San Diego region. This amounts to an expansion of employment in the county of about 1.6 percent. It means that, if all else were held equal in the San Diego region labor market over

---

[xxxvi] In fact, the ERR model from which we are generating employment estimates encompasses a broader geographic area than the San Diego region alone. The ERR model is for Southern California, which they define as including 13 counties in addition to San Diego. In order for us to produce estimates of employment impacts *within San Diego county itself*, we therefore need to work with some assumptions in defining the proportionate level of activity in San Diego County relative to all 14 counties constituting Southern California in the EER model. We describe our estimating methodology on this issue in Appendix 6.1. Because we have developed a methodology of converting their model for Southern California into estimates for San Diego County specifically, we refer throughout the chapter to the ERR model for the San Diego region.

[xxxvii] The County has retained Inclusive Economics to develop a comprehensive and coordinated regional strategy to address the workforce needs resulting from labor-market changes related to the region's Decarbonization Framework. The report will be jointly authored by Dr. Carol Zabin and Betony Jones and modelled after California's Jobs and Climate Action plan that provide recommendations on how to support San Diego's workforce as the region transitions to a carbon-neutral economy.

[xxxviii] A related profile of clean energy and fossil fuel-based employment levels in San Diego County is presented in a November 2020 spreadsheet report, *Clean and Renewable Energy in San Diego-Chula Vista-Carlsbad, CA*, by the San Diego Regional Economic Development Corporation, https://docs.google.com/spreadsheets/d/1mVZ4UXWzYG2zHu2XfnTFhXq2-1rwBBkr/edit?goal=0_c2357fd0a3-b9c8e8882a-84300641#gid=1212436047

2021 – 2030, the regional decarbonization project would itself be capable of reducing the county's unemployment rate from, say, 7.5 percent to 5.9 percent. The newly-created jobs will encompass a wide range of occupations, at all levels of the San Diego labor market. At the same time, between 2021 – 2030, we estimate that no workers in the county's fossil fuel-based industries will have to experience job displacement.

6.1. Overview of Job Creation Estimates

According to our calculations, as an average over 2021– 2030, total expenditures within the central case include $9.9 billion per year to purchase a wide range of products that operate through consuming energy, what we will term "energy demand expenditures." These include electric vehicles, heating and cooling systems, and refrigeration equipment.[xxxix] It also includes $5.1 billion per year to expand the supply of both clean renewable energy sources, including solar, wind, geothermal, and hydropower, as well as other low- to zero CO_2-emitting technologies, including nuclear power, biomass, and carbon sequestration. The average overall average spending total for both energy demand expenditures and energy supply investments, therefore, comes to an average of $15.0 billion per year between 2021 – 2030. This is equal to about 3.2 percent of San Diego's overall economic activity at its midpoint between 2021 – 2030 assuming that the San Diego County economy grows at an average annual rate of 2.5 percent over this 10-year period.

Working from these budgetary figures, we then estimate the amounts of jobs that will be created as a result of the spending amounts that EER have allocated to all categories in the areas of both energy demand and supply. Our overall findings are that an average of about 13,300 jobs per year will be generated through $9.9 billion in average annual energy demand expenditures in the region between 2021 – 2030 and another 13,400 jobs per year will be generated through spending an average of $5.1 billion per year in low- to zero-emissions technologies in the San Diego region. Overall, we estimate that the zero carbon emissions program for San Diego will generate an average of about 26,700 jobs between 2021 – 2030 in the San Diego region. This is equal to about 1.6 percent of the region's average projected labor force size between 2021 – 2030. This higher level of employment in San Diego will be sustained throughout this first decade of the county's clean energy transformation program (assuming no other major changes in the region's economy were to occur).

After estimating the number of jobs that these energy demand and supply expenditures will generate, we then present indicators of the quality of these jobs. These quality indicators

[xxxix] Appendix 1 in Pollin et al. (2020)[1] provides a full listing of all of the EER spending categories.

include average compensation levels, health care coverage, and union membership. We also provide data on the types of workers who are employed at present in the job areas that will be created by the energy demand and supply expenditures, including evidence on both educational credentials of these workers as well as their racial and gender composition. We then report on the prevalent types of jobs that will be generated through both the energy demand and supply expenditures.

6.2. Methodological Issues in Estimating Employment Creation

Before proceeding to present our detailed job creation and job quality estimates, we first briefly describe the methodology we used to generate our results.[xl]

Our employment estimates are figures generated directly with data from national surveys of public and private economic enterprises within the U.S. and organized systematically within the official U.S. input-output (I-O) model. The “inputs” within this model are all the employees, materials, land, energy and other products that are utilized in public and private enterprises within the U.S. to create goods and services. The “outputs” are the goods and services themselves that result from these activities that are then made available to households, private businesses and governments as consumers within both domestic and global markets. Within the given structure of the U.S. economy broadly and the San Diego region economy specifically, these figures from the input-output model provide the most accurate evidence available as to what happens within private and public enterprises when they produce the economy’s goods and services. In particular, these data enable researchers to observe how many workers were hired to produce a given set of products or services, and what kinds of materials were purchased in the process.

Here is one specific example of how our methodology works. When the San Diego economy expands its solar energy productive capacity by $1 billion, we are able to estimate how much of the $1 billion will be spent on hiring workers, how much will be spent on non-labor inputs, including materials, energy costs, and maintaining factory buildings, and how much will be left over for business profits. Moreover, when businesses spend on non-labor inputs, we estimate the employment effects through giving orders to suppliers, such as glass manufacturers or trucking companies.

[xl] We provide a fuller discussion of our methodology in Pollin et al. (2020)[1] Appendix 2.

Direct, Indirect and Induced Job Creation

Spending money in any area of any economy will create jobs since people are needed to produce any good or service that the economy supplies. This is true regardless of whether the spending is done by private businesses, households, or government entities. At the same time, for a given amount of spending within the economy, for example, $1 billion, there are differences in the relative levels of job creation through spending that $1 billion in alternative ways. Again, this is true regardless of whether the spending is done by households, private businesses, or public sector enterprises.

There are three sources of job creation associated with any expansion of spending—direct, indirect, and induced effects. For purposes of illustration, consider these categories in terms of investments in manufacturing electric cars or building wind turbines:

1. *Direct effects*—the jobs created, for example, by installing solar panels or purchasing electric vehicles;

2. *Indirect effects*—the jobs associated with industries that supply intermediate goods for the solar panels or electric vehicles, such as silicon, steel, and transportation;

3. *Induced effects*—the expansion of employment that results when people who are paid in the glass, steel, or transportation industries spend the money they have earned on other products in the economy. These are the multiplier effects within a standard macroeconomic model.

In this study, we report on all three employment channels—direct, indirect, and induced job creation. But we emphasize that estimating induced effects—i.e. multiplier effects—within I-O models is much less reliable than the direct and indirect effects. In addition, induced effects derived from alternative areas of spending within a national economy are likely to be comparable to one another.

Within the categories of direct plus indirect job creation, how is it that spending a given amount of money in one set of activities in the economy could generate more employment than other activities? As a matter of simple arithmetic, there are only three possibilities. These are:

1. *Labor Intensity.* When proportionally more money of a given overall amount of funds is spent on hiring people, as opposed to spending on machinery, buildings, energy, land, and other inputs, then spending this given amount of overall funds will create relatively more jobs.

2. *Compensation per worker.* If $1 billion in total is spent on employing workers in a given year on a project, and each employee earns $1 million per year working on that project, then only 1,000 jobs are created through spending this $1 billion. However, if, at another enterprise, the average pay is $50,000 per year, then the same $1 billion devoted to employing workers will generate 20,000 jobs.

3. *Local content.* When a given amount of money is spent in the San Diego in either the areas of energy supply or demand, a significant share of the funds will support activities that occur outside the county itself. Of course, job creation in San Diego itself will increase as the relative share of locally produced goods and services rises. Through the input/output model, we are able to observe the level of job creation at existing local content levels. Additionally, we can also estimate how much overall job creation will change through assuming either an increase or decrease in the local content share, resulting, for example, from active economic development policies in the county. In what follows, we report job creation levels resulting from current local content ratios.

Time Dimension in Measuring Job Creation

Jobs-per-year vs. job years. Any type of spending activity creates employment over a given amount of time. To understand the impact on jobs of given spending activity, one must therefore incorporate a time dimension into the measurement of employment creation. For example, a program that creates 100 jobs that last for only one year needs to be distinguished from another program that creates 100 jobs that continue for 10 years each. It is important to keep this time dimension in mind in any assessment of the impact on the job creation of any clean energy investment activity.

There are two straightforward ways in which one can express such distinctions. One is through measuring *job years*. This measures cumulative job creation over the total number of years that jobs have been created. Thus, an activity that generates 100 jobs for 1 year would create 100 job years. By contrast, the activity that produces 100 jobs for 10 years would generate 1,000 job years.

The other way to report the same figures would be in terms of *jobs-per-year*. Through this measure, we are able to provide detail on the year-to-year breakdown of the overall level of job creation. Thus, with the 10-year program, we are using in our example, we could express its effects as creating 100 jobs per year over the course of the 2021 – 2030 time period.

This jobs-per-year measure is most appropriate for the purposes of this study. The reason that jobs-per-year is a better metric than job years is that the impact of any new investment, whether on renewable energy or anything else, will be felt within a given set of labor market conditions at a point in time. Reporting cumulative job creation figures over multiple years prevent us from scaling the impact of investments on job markets at a given point in time. For example, as noted above, we estimate that employment creation in the region from the full set of energy demand and supply expenditures will average about 26,700 jobs per year over 2021 – 2030. We are able to scale that employment increase in the region relative to the size of the region's labor force. We estimate that the region's labor force will average about 1.7 million between 2021 – 2030. Thus, the increase of 26,700 jobs to the region's overall force of about 1.7 million jobs will amount to a growth of employment of 1.6 percent. We present the full derivation of these overall results below.

Incorporating Labor Productivity Growth over the 10-Year Investment Cycle

The figures we use for the input-output tables are based on the technologies that are prevalent at present for undertaking these clean energy investments. Yet we are estimating job creation through clean energy investments that will occur over the 10-year cycle between 2021 - 2030. The relevant production technologies will certainly change over this decade, so that a different mixture of inputs may be used to produce a given output.

For example, new technologies are likely to emerge, making other technologies obsolete. Certain inputs could also become more scarce, and, as a result, firms may substitute other less expensive goods and services to save on costs. The production process overall could also become more efficient so that fewer inputs are needed to produce a given amount of output. Energy efficiency investments do themselves produce a change in production processes—i.e. a reduction in the use of energy inputs to generate a given level of output. In short, the input-output relationships in any given economy—including its employment effects of clean energy investments—are likely to look different in 2030 relative to the present.

Pollin et al. address this issue in detail (e.g. 2015, pp. 133 - 44).[2] For the purposes of the present discussion, we work with a simple assumption: that average labor productivity in all the expenditure areas included in the ERR model will rise by 1 percent per year through until 2030.

6.3 Job Creation Estimates

Tables 6.1-6.5 report 2021-2030 job creation estimates generated by the ERR central case scenario and downscaled to the San Diego to enable the region to reach net-zero emissions by 2050.[xli] We report two overall sets of figures for both the energy demand and energy supply expenditures—first, job creation per $1 million in expenditure, then, job creation given the average annual level of spending incorporated into the ERR model, i.e. $9.9 billion per year in energy demand expenditures and $5.1 billion in energy supply investments. First, we report figures for direct and indirect jobs, along with the totals for these main job categories. Then, we include the figures on induced jobs and show total job creation when induced jobs are added to figures for direct and indirect jobs.

In Tables 6.1 and 6.2, we present our estimates as to the job creation effects generated by the full range of energy demand expenditures in the ERR central case. We have grouped this full set of projects into 10 categories: vehicles, heating/ventilation/air conditioning (HVAC), manufacturing, other commercial and residential spending, construction, appliances, refrigeration, mining, agriculture and lighting.[xlii] As Table 6.1 shows, direct plus indirect job creation per $1 million in spending range from 0.7 for mining to 10.0 for agriculture.

In Table 6.2, we show the level of job creation through spending an average of $9.9 billion per year on the full set of these projects between 2021 and 2030. As we see, of the full $9.9 billion average annual spending figure, the largest areas of expenditures include (with rounding): $7.7 billion on clean energy vehicles, $897 million on high-efficiency HVAC systems and $762 million on refrigeration equipment. These three spending categories, therefore, account for roughly 95 percent of total demand expenditures, with spending on clean energy vehicles alone accounting for 78 percent of all demand-side expenditures.

[xli] See Appendix A, Table 1 of the RDF report for more information on the Central Case. See Appendix 6.A.1 of this chapter for more information on downscaling Southern California data to the San Diego region.

[xlii] The "other" commercial and residential category of energy demand expenditures is taken directly from the ERR model—or, more precisely, this category combines the "commercial other" and "residential other" categories within the ERR model.

Table 6.1. Job Creation through Energy Demand Expenditures in San Diego, by Subsectors and Technology. Job creation per $1 million in spending.

Investment Area	Direct Jobs	Indirect Jobs	Direct Jobs+ Indirect Jobs	Induced Jobs	Direct Jobs+ Indirect Jobs+ Induced Jobs
Vehicles	0.47	0.19	0.66	0.21	0.87
HVAC	1.57	0.82	2.39	0.89	3.28
Refrigeration	1.81	0.68	2.49	0.98	3.47
Appliances	0.79	0.43	1.22	0.43	1.65
Construction	2.43	1.38	3.81	1.35	5.16
Lighting	1.74	0.93	2.67	0.98	3.65
Manufacturing	0.91	0.72	1.63	0.63	2.26
Other commercial and residential	1.6	0.8	2.4	0.9	3.3
Agriculture	8.78	1.27	10.05	2.74	12.79
Mining	0.39	0.33	0.72	0.34	1.06

Note: These figures are based on current rates of job creation, weighted by total investment amounts over 2021-2030. Source: IMPLAN 3.1

Table 6.2. Average Number of Jobs Created in the San Diego Region Annually through Energy Demand Expenditures from 2021-2030, by Subsectors and Technology. Figures assume 1 percent average annual productivity growth.

Investment Area	Average Annual Expenditure	Direct Jobs	Indirect Jobs	Direct Jobs + Indirect Jobs	Induced Jobs	Direct Jobs + Indirect Jobs + Induced Jobs
Vehicles	$7.7 billion	3,427	1,427	4,854	1,508	6,362
HVAC	$897.0 million	1,345	699	2,044	764	2,808
Refrigeration	$761.9 million	1,315	491	1,806	711	2,517
Appliances	$188.6 million	143	77	220	78	298
Construction	$113.4 million	263	149	412	146	558
Lighting	$106.6 million	177	95	272	100	372
Manufacturing	$45.7 million	40	32	72	27	99
Other commercial and residential	$38.9 million	59	30	89	33	122
Agriculture	$17.2 million	144	21	165	45	210
Mining	$2.4 million	1	1	2	1	3
TOTAL	$9.9 billion	6,914	3,022	9,936	3,413	13,349

Source: IMPLAN 3.1

The result of the demand expenditures at this level will be the creation of an average of about 6,914 direct jobs and 3,022 indirect jobs, for an average between 2021 and 2030 of 9,936 direct plus indirect jobs. Including induced jobs adds another 3,413 jobs per year to the total figure. This brings the total net job creation figure for the full set of energy demand expenditures, including induced jobs, to about 13,400 as an annual average figure between 2021 – 2030.

In Tables 6.3 and 6.4, we present our estimates as to the job creation effects generated by the full set of energy supply projects presented in the ERR model for San Diego County between 2021 - 2030. These include clean renewables, transmission and storage; fossil fuels; additional supply technologies, including nuclear, carbon sequestration and biomass; and grouping of difficult to categorize "other" investments.[xliii] By far, the largest share of investments assigned by the ERR model over 2021 – 2030 is in the fossil fuel category.
In Table 6.3, we see that the extent of direct plus indirect jobs ranges from 1.2 jobs per $1 million in spending for "other investments" to 3.5 jobs per million for both the fossil fuel and clean renewables investment categories. Adding induced jobs brings the range to between 1.9 jobs for other investments to 4.9 for fossil fuels and clean renewables.

Table 6.3. Job Creation through Energy Supply Expenditures in San Diego, by Subsectors and Technology. Job creation per $1 million in spending.

Investment Area	Direct Jobs	Indirect Jobs	Direct Jobs+ Indirect Jobs	Induced Jobs	Direct Jobs+ Indirect Jobs+ Induced Jobs
Fossil fuels	2.73	0.81	3.54	1.33	4.87
Clean renewables	2.47	1.00	3.47	1.41	4.88
Transmission and storage	0.61	0.90	1.51	0.91	2.42
Additional supply technologies	2.35	0.79	3.14	1.27	4.41
Other investments	0.77	0.38	1.15	0.70	1.85

Note: These figures are based on current rates of job creation, weighted by total investment amounts over 2021-2030. Source: IMPLAN 3.1

[xliii] Our energy supply expenditure "other" category includes electric boilers, hydrogen blend, industrial CO2 capital, other boilers, and steam production.

Based on these proportions, we see in Table 6.4 the levels of job creation in the San Diego region associated with $5.1 billion in average annual spending on these energy supply investments between 2021 - 2030. As noted above, the highest proportion of spending among the supply side investments is in the fossil fuel area, at $4.4 billion of the $5.1 billion total—i.e. amounting to about 86 percent of total spending. Spending on clean renewables totals to an average of $630 million per year, equal to another 12.3 percent of the total. Thus, the spending on fossil fuels and clean renewables together accounts for fully 98 percent of all spending on the supply side between 2021 – 2030 in the ERR model.

Within these budgetary allocations, we see first in Table 6.4 that total direct plus indirect job creation generated in the San Diego region by this specific expansion in energy supply expenditures will amount to an average of about 4,200 direct jobs and 4,400 indirect jobs per year between 2021 – 2030. This totals to about 8,600 direct and indirect jobs. We also estimate that, as an average between 2021 – 2030, an additional 4,700 induced jobs will be generated in San Diego by these investments. This brings the total of direct, indirect and induced jobs generated by net energy supply investments to about 13,400 jobs.

Table 6.4. Average Number of Jobs Created in the San Diego Region Annually through Energy Supply Expenditures from 2021-2030, by Subsectors and Technology. Figures assume 1 percent average annual productivity growth.

Investment Area	Average Annual Expenditure	Direct Jobs	Indirect Jobs	Direct Jobs+ Indirect Jobs	Induced Jobs	Direct Jobs+ Indirect Jobs+ Induced Jobs
Fossil fuels	$4.4 billion	2,538	3,777	6,315	3,805	10,120
Clean renewables	$629.5 million	1,488	601	2,089	848	2,937
Transmission and storage	$45.9 million	34	17	51	31	82
Additional supply technologies	$45.1 million	118	35	153	57	210
Other investments	$4.5 million	10	3	13	6	19
TOTAL	$5.1 billion	4,188	4,433	8,621	4,747	13,368

Source: IMPLAN 3.1

Tables 6.5A and 6.5B bring together our job creation estimates for both the energy supply investments and energy demand expenditures. In Table 6.5A, we first present the figures for 2021 – 2030, our time period of focus. Table 6.5B then presents the same set of aggregate employment figures for the full period of the ERR model, i.e. 2020 – 2050.

In Table 6.5A, we show the total job creation estimates through spending an average of $15.0 billion per year from 2021 --2030. We first report figures for direct plus indirect jobs only, then we also show the total when induced jobs are included.

Table 6.5. Estimated Average Annual Job creation in San Diego County through Combined Energy Supply and Energy Demand Expenditure Program

Table 6.5A. Figures for 2021-2030

	Number of Direct and Indirect Jobs	Number of Direct, Indirect, and Induced Jobs
1. $9.9 billion in average annual energy demand investments	9,936	13,349
2. $5.1 billion in average annual energy supply investments	8,621	13,368
3. $15.0 in average annual energy demand investments	18,557	26,717
4. Total job creation as a share of projected 2026 labor force *(projection is 1.68 million San Diego county labor force for 2026)*	1.1%	1.6%

Note: Figures assume 1 percent average annual labor productivity growth. Source: Figures derived from ERR energy model for Southern California.

Table 6.5B. Figures for 2020 - 2050

	Number of Direct and Indirect Jobs	Number of Direct, Indirect, and Induced Jobs
1. $4.4 billion in average annual energy supply investments	8,868	13,985
2. $11.4 billion in average annual energy demand expenditures	12,922	17,425
3. $15.8 billion in average annual combined expenditures	21,791	31,412
4. Total job creation as share of projected 2035 labor force *(Projection is 1.9 million San Diego County labor force for 2035)*	1.1%	1.7%

Note: Figures assume 1 percent average annual labor productivity growth. Source: Figures derived from ERR energy model for Southern California Energy demand figures are averages for 2018 – 2050.

We see in row 3 of Table 6.5A that total average direct and indirect job creation between 2021 – 2030—including jobs generated on both the supply and demand sides of the energy transformation—is, as discussed above, 18,557. Through adding induced jobs, the average annual job creation figures then rise to 26,717. As we see in row 4, this level of direct and indirect job creation would amount to about 1.1 percent of the likely San Diego region County labor force as of 2026. When we include induced jobs in the total, we reach 1.6 percent of the likely size of the county's 2026 labor force.

Not surprisingly, the patterns we report in Table 6.5B, covering the full period 2020 – 2050, parallel those shown in Table 6.5A. For the full 2020 – 2050 period, the average annual spending level rises to $15.8 billion, since spending levels increase in the later years of the ERR model. With average spending levels rising, the extent of job creation through the decarbonization project rises correspondingly. Thus, direct and indirect employment between 2020 – 2050 rises to an average of 21,791. When we include induced job creation, average annual employment increases rise to 31,214. These greater average employment levels remain at basically the same size relative to the overall San Diego County labor force—i.e. at 1.1 percent of the labor force for direct and indirect jobs only and at 1.7 percent when we include induced jobs. These stable shares of the overall San Diego labor force reflect the fact that the San Diego County labor force is growing over this full 2020 – 2050 period, along with the average level of spending within the region on its decarbonization project.

6.4. Job Quality Indicators in Energy Demand and Supply Employment

In Table 6.6 – 6.9, we provide some basic measures of job quality for the direct jobs in the core areas that will be generated through both the energy demand expenditures and energy supply investments within the ERR central case for the San Diego region. These basic indicators include: 1) average total compensation (including wages plus benefits) for wage-earning employees; 2) the percentage of workers receiving health insurance coverage through their employer; and 3) the percentage that are union members. We first present these figures for the energy demand categories in Tables 6.6 and 6.7, then for the energy supply investments in Tables 6.8 and 6.9

Energy Demand Expenditures and Job Quality

We focus here on figures for the three major energy demand expenditure areas—i.e. vehicles, HVAC, and refrigeration. These three spending categories comprise roughly 95 percent of all spending on energy demand between 2021 – 2030.

Starting with compensation figures, we see in Table 6.6 that the averages for the energy demand expenditures range between roughly $62,000 per year for workers in the vehicles' category to nearly $78,000 in the refrigeration category.

Table 6.6. Indicators of Job Quality in Energy Demand Investment Areas: Direct Jobs Only.

Investment Area	Average total compensation*	Health insurance coverage, percentage**	Union membership, coverage***
Vehicles	$62,000	58.2%	14.2%
HVAC	$72,000	53.8%	12.4%
Refrigeration	$77,600	55.2%	14.5%
Appliances	$70,800	51.1%	14.0%
Construction	$73,200	51.9%	13.0%
Lighting	$73,800	50.9%	14.2%
Manufacturing	$71,800	64.9%	7.3%
Other commercial and residential	$73,800	53.4%	13.2%
Agriculture	$59,500	44.7%	4.6%
Mining	$61,700	76.3%	NA

Source: CPS 2015-2019, ACS 2015-2019, IMPLAN 3.1.

Notes: *Compensation figures reflect only wage and salary workers, and excludes proprietors' compensation, in San Diego County. This is because wage and salary workers' employment in these activities serve as their primary jobs, whereas proprietors' employment in these activities are more likely to serve only as secondary jobs. **Health insurance coverage is based on workers within San Diego County plus the five surrounding counties that supply San Diego County with the highest numbers of commuting workers. These counties include: Imperial County, Los Angeles County, Orange County, Riverside County, and San Bernardino County. *** Union membership is based on workers in the southern region of California. "NA": the sample size is too small to generate a reliable union coverage estimate of workers in mining.

The share of workers receiving health insurance coverage is comparable for these major energy demand areas, ranging between 54 percent for HVAC to 58 percent for vehicles. Similarly, the level of union membership is also comparable, ranging between about 12 – 14 percent of the workforce in the area.

Educational Credentials and Race/Gender Composition

In Table 6.7, we present data on both the educational credentials and race/gender composition for workers employed in the full range of energy demand categories. We focus on the workers in the three core energy efficiency expenditure categories of vehicles, HVAC, and refrigeration, as well as the race and gender composition of these workers. We categorize all workers according to three educational credential groupings: 1) shares with high school degrees or less; 2) shares with some college or Associate degrees; and 3) shares with a Bachelor's degree or higher.

Table 6.7. Educational Credentials and Race/Gender Composition of Workers in Energy Demand Investment Areas: Direct Jobs Only.

	Educational Credentials			**Racial and Gender Composition**	
Investment Area	% with high school degree or less	% with some college or Associate degree	% with Bachelor's degree or higher	% BIPOC workers	% Women workers
Vehicles	45.0%	32.7%	22.3%	70.0%	20.8%
HVAC	58.8%	26.9%	14.2%	70.0%	12.2%
Refrigeration	60.5%	27.7%	11.8%	70.4%	10.7%
Appliances	59.7%	26.7%	13.6%	69.9%	10.5%
Construction	61.3%	25.5%	13.1%	70.2%	10.9%
Lighting	59.8%	26.6%	13.6%	70.1%	10.4%
Manufacturing	51.0%	24.0%	25.1%	74.6%	32.6%
Other commercial and residential	59.3%	27.0%	13.8%	70.0%	11.6%
Agriculture	65.4%	22.0%	12.5%	75.4%	37.2%
Mining	55.8%	20.2%	24.0%	71.1%	17.1%

Sources: ACS 2015-2019, IMPLAN 3.1.

Note: All characteristics in this table are based on workers within San Diego County plus the five surrounding counties that supply San Diego County with the highest numbers of commuting workers. These counties include: Imperial County, Los Angeles County, Orange County, Riverside County, and San Bernardino County. For reference, across these counties, nonwhite workers make up 65.9% of the employed and women workers make up 45.9%

As Table 6.7 shows, the distribution of educational credentials is fairly consistent across the major energy demand spending categories. Thus, the range of workers with high school degrees or less varies from a low of 45 percent for workers employed in the vehicles category to 61 percent in refrigeration. Similarly, the share of workers with Bachelor's degrees or higher ranges from a low of 12 percent in refrigeration to 22 percent in the vehicles category.

It is clear from the figures in Table 6.7 that, at present, most jobs created by energy demand expenditures in San Diego County are primarily held by people of color (BIPOC), at about 70 percent of the total. With respect to gender composition, women are under-represented across all sectors. The share of female employment is between 11 – 21 percent in the major energy demand areas of vehicles, HVAC, and refrigeration, even while women make up 46 percent of the San Diego area workforce. [xliv]

Energy Supply Investments and Job Quality

Tables 6.8 and 6.9 present the job quality and demographic figures for all of the supply investment categories in the ERR model. We focus on the two core areas of expenditures on the supply side of their model, i.e. fossil fuels and clean renewables.

As we see first in Table 6.8, compensation for workers in San Diego's fossil fuel industry is high, with pay averaging nearly $190,000. This figure is clearly well above any of the employment categories on the demand side of the ERR model, where the range for the three main categories is between $62,000 and $78,000. Average compensation in clean renewables, at roughly $100,000, is well below that for workers in the fossil fuel industry, but still significantly higher than the averages for the energy demand categories.

In terms of the provision of employer-sponsored health care, the coverage rate is 83 percent for fossil fuel workers and 60 percent for those in clean renewables. The unionization rates are relatively high in these two largest energy supply areas, at 18 percent in the fossil fuel sector and 11 percent in clean renewables. These figures are close to those for the main areas of energy demand.

[xliv] In addition to the share of female employment in the San Diego County workforce, we estimate the share of the area's workforce that is non-White (including Latinx) is 66 percent.

Table 6.8. Indicators of Job Quality in Energy Supply Investment Areas: Direct Jobs Only.

Investment Area	Average total compensation*	Health insurance coverage, percentage**	Union membership, coverage***
Fossil fuels	$181,800	82.9%	18.1%
Clean renewables	$97,600	59.5%	11.0%
Transmission and storage	$69,700	69.4%	15.6%
Additional supply technologies	$75,100	51.3%	14.9%
Other investments	$75,900	55.8%	12.9%

Source: CPS 2015-2019, ACS 2015-2019, IMPLAN 3.1.
Notes: *Compensation figures reflect only wage and salary workers, and exclude proprietors' compensation, in San Diego County. This is because wage and salary workers' employment in these activities serves as their primary jobs, whereas proprietors' employment in these activities is more likely to serve only as secondary jobs. **The health insurance coverage estimate is based on workers within San Diego County plus the five surrounding counties that supply San Diego County with the highest numbers of commuting workers. These counties include: Imperial County, Los Angeles County, Orange County, Riverside County, and San Bernardino County. *** The union density measure is based on 14 counties that make up the southern region of California. These include: Fresno, Imperial, Inyo, Kern, Kings, Los Angeles, Mono, Orange, Riverside, San Bernardino, San Diego, Santa Barbara, Tulare and, Ventura.

Educational Credentials and Race/Gender Composition

In Table 6.9, we present data on both the educational credentials as well as the race and gender composition of the workers employed in the supply-side areas of the ERR model. We again focus here only on the workers who are employed *directly* through these investments.

As Table 6.9 shows, in the fossil fuel sector, the educational attainment level of the industry's workforce is evenly divided between those without high school degrees or less, those with some college, and those with Bachelor's degrees or higher. In clean renewables, there is one major difference, in that nearly half of the workers have only high school degrees or less.

In terms of the share of workers who are black, indigenous and people of color (BIPOC), the percentages remain high in all of the supply expenditure categories, including the largest ones—i.e. with 64 percent of the fossil fuel workforce and 65 percent of the clean renewable workforce being BIPOC.

Women remain underrepresented in both of these main areas of supply-side expenditures, at 23 percent for fossil fuels and 19 percent in clean renewables.

Table 6.9. Educational Credentials and Race/Gender Composition of Workers in Energy Supply Investment Areas: Direct Jobs Only.

	Educational Credentials			**Racial and Gender Composition**	
Investment Area	% with high school degree or less	% with some college or Associate degree	% with Bachelor's degree or higher	% BIPOC workers	% Women workers
Fossil fuels	31.1%	35.6%	33.4%	62.7%	23.0%
Clean renewables	46.5%	23.4%	30.1%	64.8%	19.0%
Transmission and storage	40.6%	28.7%	30.7%	65.1%	20.4%
Additional supply technologies	58.8%	26.6%	14.6%	71.2%	21.5%
Other investments	51.9%	25.8%	22.3%	66.1%	16.3%

Sources: ACS 2015-2019, IMPLAN 3.1.

Note: All characteristics in this table are based on workers within San Diego County plus the five surrounding counties that supply San Diego County with the highest numbers of commuting workers. These counties include: Imperial County, Los Angeles County, Orange County, Riverside County, and San Bernardino County. For reference, across these counties, nonwhite workers make up 65.9% of the employed and women workers makeup 45.9%.

Prevalent Job Types with Energy Demand and Supply Employment

In addition to these average results across the various energy supply investment and energy demand expenditure areas, it is important to consider the range of the types of jobs that will be generated in each of the specified areas. To provide a picture of this range of jobs, in Tables 6.10A-6.10C and 6.11A – 6.11B, we present figures on more specific job categories in all of the investment and expenditure areas. It is difficult to summarize the detailed data on job categories presented in these tables, butut the overall point is clear. That is, investing to build a clean energy economy will produce new employment opportunities at all levels of the San Diego economy. New job opportunities will open for, among other occupations, carpenters, machinists, chemists, environmental scientists, secretaries, accountants, heating installers, truck drivers, pipe layers and construction laborers, as well as a full range of managerial occupations. At the same time, at least over the period 2021 – 2030, most fossil-fuel-based employment remains intact in the ERR model. This is evident from the energy supply figures we reported in Table 6.4, which shows that 10,120 of the 13,368 jobs generated by supply investments in the ERR model between 2021 – 2030—i.e. roughly 75 percent of the total—will be in the fossil fuel area.

Table 6.10. Prevalent Job Categories Generated through Energy Demand Expenditures

Table 6.10A. Vehicles: Prevalent Job Types: (Job categories with 5 percent or more employment)

Job Category	Percentage of Total Industry Employment	Representative Occupations
Transportation and material moving	38.2%	Order fillers; freight movers; bus drivers
Construction	13.7%	Electricians; carpenters; construction laborers
Production	13.6%	First-line supervisors; welding workers; electrical assemblers;
Management	9.3%	General managers; marketing managers; construction managers
Office and administrative support	7.0%	Dispatchers; bookkeeping clerks; administrative assistants

Sources: ACS 2015-2019, IMPLAN 3.1.

Table 6.10B. HVAC: Prevalent Job Types: (Job categories with 5 percent or more employment).

Job Category	Percentage of Total Industry Employment	Representative Occupations
Construction	53.0%	Electricians, first-line supervisors; painters
Management	13.2%	Chief executives; operations managers; sales managers
Production	9.5%	First-line supervisors; brazing workers; assemblers
Office and administrative support	6.3%	Shipping clerks; accounting clerks; general office clerks

Sources: ACS 2015-2019, IMPLAN 3.1.

Table 6.10C. Refrigeration: Prevalent Job Types: (Job categories with 5 percent or more employment).

Job Category	Percentage of Total Industry Employment	Representative Occupations
Construction	34.2%	First-line supervisors; painters; construction laborers
Production	21.4%	Inspectors; machinists; soldering workers
Installation and maintenance	15.5%	General maintenance workers; heating installers; heavy vehicle technicians
Management	8.9%	Marketing managers; operations managers; chief executives
Office and administrative support	6.6%	Inventory clerks; general office clerks; auditing clerks

Sources: ACS 2015-2019, IMPLAN 3.1.

Table 6.11. Prevalent Job Categories Generated through Energy Supply Expenditures.

Table 6.11A. Fossil Fuels: Prevalent Job Types: (Job categories with 5 percent or more employment).

Job Category	Percentage of Total Industry Employment	Representative Occupations
Office and administrative support	14.3%	Production clerks; executive secretaries; utility meter readers
Production	13.9%	Welding workers; inspectors; first-line supervisors
Management	11.5%	Financial managers; computer systems managers; general managers
Construction	10.5%	Construction equipment operators; electricians; pipelayers
Architecture and engineering	8.0%	Industrial engineers; mechanical engineers; petroleum engineers
Installation and maintenance	7.2%	Mobile equipment service technicians; truck mechanics; valve installers
Transportation and material moving	7.1%	Pumping station operators; freight movers; driver/sales workers
Extraction	6.4%	Earth drillers; explosive workers; derrick operators

Sources: ACS 2015-2019, IMPLAN 3.1.

Note: This table is based on workers within San Diego region, plus the five surrounding counties that supply San Diego County with the highest numbers of commuting workers. These counties include: Imperial County, Los Angeles County, Orange County, Riverside County, and San Bernardino County.

Table 6.11B. Clean Renewables: Prevalent Job Types: (Job categories with 5 percent or more employment).

Job Category	Percentage of Total Industry Employment	Representative Occupations
Construction	46.6%	Electricians, first-line supervisors; painters
Management	14.2%	Operations managers; sales managers; construction managers
Life, physical and social science	8.0%	Chemical scientists; material scientists; biological scientists
Office and administrative support	6.2%	Customer service representatives; auditing clerks; general office clerks

Sources: ACS 2015-2019, IMPLAN 3.1.

Note: This table is based on workers within San Diego region, plus the five surrounding counties that supply San Diego County with the highest numbers of commuting workers. These counties include: Imperial County, Los Angeles County, Orange County, Riverside County, and San Bernardino County.

Nevertheless, over this same period, San Diego's fossil fuel economy will undertake its first, if relatively modest, steps toward a near-total phase-out by 2050. As such, we now turn to the issues around fossil fuel job contraction over the 2021 – 2030 period.

6.5. Job Contraction for Workers in Fossil Fuel-Based Industries

The transition for the San Diego region into a zero-emissions economy by 2050 will of course entail the phasing out of burning oil, coal and natural gas to produce energy. In Table 6.12, we show the rates of contraction for oil, coal and natural gas within the ERR model. As the table shows, through 2030, the contraction rates for oil and gas in the ERR model are quite modest. Indeed, natural gas consumption in the ERR model does not decline at all through 2030, while the consumption of oil falls by only 20 percent. Coal is not consumed at all as an energy source as of 2030 in ERR, but the level of coal consumption in San Diego County, and throughout California more generally, is already close to zero at present.

Table 6.12. Assumptions on Contraction Rates for San Diego County Fossil Fuel Sectors: Contractions as of 2030 and 2050. Baseline Employment Figures from 2018.

	2030	2050
Oil	-20%	-95%
Natural Gas	No contraction	-75%
Coal	-100%	-100%

Note: Contraction rates for the San Diego region within ERR model.

As Table 6.12 shows, the major contractions in oil and gas consumption in San Diego County will occur between 2031 – 2050 within the ERR model. But this latter period is not the primary focus of our analysis in this chapter. We focus here on the contraction process in oil and gas through 2030 in the San Diego region, as it impacts on employment in the county.

Current Levels of Fossil Fuel-Based Employment

Table 6.13 shows the most recent figures on employment levels for all fossil fuel and ancillary industries in San Diego County. As we see, total fossil fuel-based employment in San Diego County as of 2018 is 9,239. This amounts to about 0.6 percent of total employment in the county as of 2018. Of this total level of employment, we also see that 6,434 of the total, amounting to nearly 70 percent of all the fossil fuel-based jobs in the county, are in natural gas distribution. Another 1,418 jobs, about 15 percent of the total, are in oil and gas extraction. About 5 percent of the total are in wholesale distribution of oil. In short, roughly 90 percent of all fossil fuel-based employment in San Diego County is in these three areas—first, and most importantly, natural gas distribution, then to a lesser extent, oil and gas extraction as well as the wholesale distribution of petroleum products.[xlv]

[xlv] We should note that the ancillary fossil fuel-based industries listed in Table 13 approximately match up with the industries in which *indirect employment* occurs resulting through fossil fuel sector production, as defined in the input-output tables, and as we have described above. In estimating the number of workers who might experience job displacement, it is more accurate to focus on the direct employment figures for these ancillary fossil fuel industries, as opposed to utilizing the indirect employment data from the input-output tables. With the data reported on in Table 13, we are able to incorporate important details on employment conditions in these ancillary industries by working with the available employment data on the specific industries, as opposed to relying on a single generic category of indirect employment for the oil/gas and coal industries. At the same time, for the purposes of drawing comparisons with the figures we have presented above on employment creation through clean energy investments, it is useful to keep in mind that the figures we are reporting here on ancillary employment relative to the oil/gas and coal industries are the equivalent of the indirect employment figures we report in the clean energy industries.

Table 6.13. Number of Workers in San Diego County Employed in Fossil Fuel-Based Industries, 2018

Industry	2018 Employment Levels	Industry share of total fossil fuel-based employment
Natural gas distribution	6,434	69.6%
Oil and gas extraction	1,418	15.4%
Wholesale -petroleum and petroleum products	491	5.3%
Support activities for oil/gas	228	2.5%
Oil and gas pipeline transportation	218	2.4%
Support activities for coal	177	1.9%
Drilling oil and gas wells	118	1.3%
Oil and gas field machinery and equipment manufacturing	45	0.5%
Fossil fuel electric power generation	41	0.4%
All other petroleum and coal products manufacturing	32	0.3%
Petroleum refining	29	0.3%
Oil and gas pipeline construction	8	0.1%
Mining machinery and equipment manufacturing	0	0.0%
Coal mining	0	0.0%
Fossil fuel industry total	9,239	100.0%
TOTAL FOSSIL FUEL EMPLOYMENT AS SHARE OF SAN DIEGO EMPLOYMENT ***(San Diego County 2018 employment = 1,464,125)***		0.63%

Source: IMPLAN 3.0. U.S. Department of Labor.

Characteristics of Fossil Fuel and Ancillary Industry Jobs

Table 6.14 provides basic figures on the characteristics of the jobs in fossil fuel-based industries. As the table shows, on average, these are relatively high-quality jobs. The average overall compensation level is $212,900. Of course, this figure is 2 – 3 times higher than any of the energy demand sectors, as reported in Table 6.6. It is also more than twice as high as the average compensation level in renewable energy.

Table 6.14. Characteristics of Workers Employed in San Diego County's Fossil Fuel-Based Sectors.

	Fossil Fuel-Based industries
Average total compensation	$212,900
Health insurance coverage	86.8%
Union membership coverage*	21.9%
Educational credentials	
Share with high school degree or less	25.2%
Share with some college or Associate degree	36.3%
Share with Bachelor's degree or higher	38.5%
Racial and gender composition of workforce	
Pct. BIPOC workers	62.4%
Pct. female workers	26.1%

Source: ACS 2015-2019; CPS ORG 2015-2019.
Note: All the estimates aside from the compensation figures and union membership coverage—in this table are based on data from the ACS. Compensation figures are from IMPLAN and are for San Diego County. The estimates for the other characteristics are based on data from workers in San Diego County plus the five surrounding counties that supply San Diego County with the highest numbers of commuting workers. These counties include: Imperial County, Los Angeles County, Orange County, Riverside County, and San Bernardino County. The one exception is the union measure. The ACS does not ask about union membership. The union coverage measure is estimated from the ORG files of the CPS, which have smaller sample sizes than the ACS. To construct an adequate sample size, the union density measure is based on 14 counties that make up the southern region of California. These include: Fresno, Imperial, Inyo, Kern, Kings, Los Angeles, Mono, Orange, Riverside, San Bernardino, San Diego, Santa Barbara, Tulare and, Ventura.

The figure is even roughly $30,000 higher than the $182,000 average compensation figure we report in Table 6.8 for the supply-side investments in the fossil fuel sector itself. The reason that Table 6.8 and 6.14 figures are not identical, even though they both are showing compensation figures in the fossil fuel sector, is that the mix of specific spending areas within the supply investment categories is not the same as the current overall profile of employment in the county's fossil fuel sectors.

Workers in these industries are also relatively well off in terms of the benefits they receive from their jobs. Nearly 90 percent of them receive health insurance from their jobs. Union membership is at nearly 22 percent. This figure is more than 3 times higher than average for the entire U.S. private sector, at only 6.2 percent. Again, these figures are largely reflecting the favorable working conditions in the natural gas distribution industry in the region.

Table 6.14 also reports figures on educational credential levels for workers in each of the fossil fuel-based industries, as well the percentages of non-white and female workers. The jobs are distributed fairly evenly with respect to educational credentials, with 25 percent of workers having high school degrees or less, 36 percent having some college and 39 percent with Bachelor's degrees or higher. The percentage of non-white workers (BIPOC) in these areas of employment is also high, at 62 percent of the workforce. However, the share of female workers is low, at only 26 percent of the total.

We provide more specifics on the composition of the workforce in the fossil fuel-based industries in Table 6.15, in which we list all the job categories in which 5 percent or more of the workforce is employed. As we see, the highest percentage of jobs, at 18.6 percent, are in office and administrative support, including dispatchers, production clerks and meter readers. Various forms of management are the next largest category of employment in the fossil fuel-based industries in San Diego, at 12.4 percent. Next comes production workers, at 10.6 percent of all employment. The representative occupations in these jobs include welding workers, inspectors and first-line supervisors.

Generally speaking, as with the areas of employment in on both the demand and supply sides of the ERR expenditure program, we see that San Diego County's fossil fuel-based industries employ a wide range of workers. Some of them will have skills specific to the industry and will therefore face difficulties moving into new employment areas. But the majority of the workers will have jobs that should be transferable to new employment opportunities, in the clean energy economy or elsewhere.

Table 6.15. Prevalent Job Types in San Diego County's Fossil Fuel-Based Industries (Job categories with 5 percent or more employment).

Job Category	Percentage of Direct Jobs Lost	Representative Occupations
Office and administrative support	18.6%	Dispatchers; production clerks; meter readers
Management	12.4%	Financial managers; computer and information systems managers; chief executives
Production	10.6%	Welding workers; inspectors; first-line supervisors
Construction	9.9%	Construction equipment operators; electricians; construction laborers
Architecture and engineering	8.7%	Surveying technicians; mechanical engineers; petroleum engineers
Installation and maintenance	8.6%	Precision instrument and equipment repairers; truck mechanics; control and valve installers
Transportation	5.6%	Motor vehicle operators; pumping station operators; freight movers
Computer and mathematical science	5.3%	Computer programmers; computer systems analysts; software developers

Source: ACS 2015-2019. These estimates are based on data from workers in San Diego County plus the five surrounding counties that supply San Diego County with the highest numbers of commuting workers. These counties include: Imperial County, Los Angeles County, Orange County, Riverside County, and San Bernardino County.

Estimating Annual Job Losses through Fossil Fuel Contraction

For understanding the impact on employment of the phase-down of the fossil fuel-based industries in San Diego County (and elsewhere), the most relevant metric will be the rate at which workers are likely to be losing their jobs through the phase-down. Within the ERR model described in Chapter 1 and Appendix A, we have seen that, by 2030, the level of oil consumption will be 20 percent lower than at present, while natural gas consumption will remain stable. We have also reported in Table 6.8 that, through the supply-side investments in the ERR model, over 6,000 new jobs will be generated on average between 2021 – 2030 in the county's fossil fuel sectors. Nevertheless, the contraction of the county's consumption of oil by 20 percent will engender some job losses.

Moreover, the assumption in ERR of a stable level of natural gas consumption in the San Diego region is crucial since, as we have seen, roughly 70 percent of the 9,239 fossil fuel industry-based jobs in the county are in the natural gas distribution sector. Most of these jobs will remain at current levels through 2030. However, some employment losses will result in this sector before2030 because, while consumption of natural gas will remain stable through 2030, there will also be no need to expand the region's natural gas distribution infrastructure. Rather, the region's existing natural gas distribution channels should remain adequate through 2030, given the county's stable natural gas consumption level. As such, it is reasonable to assume that the construction industry jobs associated with San Diego's natural gas industry—jobs that would be tied to the expansion of the sector—will be phased out by 2030. We have incorporated this factor into our estimate below of the overall fossil fuel-based industry employment losses through 2030.

We, therefore, estimate the total number of jobs that will be phased out in San Diego's fossil fuel-based industries through 2030, based on the assumptions that: 1) oil consumption declines by 20 percent; 2) natural gas consumption remains constant; and 3) construction activity in the natural gas sector falls to zero. We also incorporate two other considerations in generating the job contraction estimates for the county's fossil fuel-based sectors. These are: 1) the attrition rate in the sector's labor force due to voluntary retirements; and 2) whether the rate of contraction will be steady or episodic.

Labor force attrition through voluntary retirements. About 80 percent of workers in the U.S. fossil fuel-based industries choose to retire voluntarily once they reach age 65. As San Diego's fossil fuel-based industries contract, the workers employed in the industry who are choosing to retire will, of course, not experience job losses, in contrast with those workers, of all ages, who are not choosing to retire. As such, to the extent that the rate of voluntary retirements in the industry counterbalances against the rate at which the industry is contracting, the extent of job losses and displacement experienced by workers in the industry will be correspondingly reduced. It, therefore, becomes an important component of our estimate of job losses in the sector to take account of the rate of voluntary retirements per year in the industry.

Steady versus Episodic Industry Contraction. The scope and cost of any set of policies to manage a just transition for impacted workers will depend heavily on whether the contraction is steady or episodic. Under a pattern of steady contraction, there will be uniform annual employment losses over both the 2020 – 2030 and 2031 – 2050 periods, with the steady rates determined by the overall level of industry contraction within the given time period. But it is not realistic to assume that the pattern of industry contraction will necessarily proceed at a steady rate. An alternative pattern would entail relatively large episodes of employment contraction, followed by periods in which no further employment losses are experienced. This type of pattern would occur if, for example, one or more relatively large firms were to undergo large-scale cutbacks at one point in time as the industry overall contracts, or even for such firms to shut down altogether.

The costs of a just transition will be much lower if the transition is able to proceed steadily rather than through a series of episodes. One reason is that, under a steady transition, the proportion of workers who will retire voluntarily in any given year will be predictable. This will enable the transition process to avoid having to provide support for a much larger share of workers. The share of workers requiring support would rise if several large businesses were to shut down abruptly and lay off their full workforce at once, including both younger as well as older workers Similarly, it will be easier to find new jobs for displaced workers if the pool of displaced workers at any given time is smaller.

For the purposes of our calculations, we proceed by assuming that the San Diego region will successfully implement a relatively smooth contraction of its fossil fuel industries. This indeed would be one important feature of a well-designed and effectively implemented just transition program. As a practical matter, a relatively smooth transition should be workable as long as policymakers remain focused on that goal.

Incorporating these considerations, in Table 6.16, we show figures on annual employment reductions in the county's fossil fuel-based industries over 2021 – 2030. We also then estimate the proportion of workers who will move into voluntary retirement at age 65 as of 2030. Once we know the share of workers who will move into voluntary retirement at age 65, we can then estimate the number of workers who will be displaced through the industry-wide contraction.

Table 6.16. Attrition by Retirement and Job Displacement for Fossil Fuel Workers in San Diego County, 2021-2030.

	Fossil Fuel Workers
1) Total workforce as of 2018	9,239
2) Job losses over 10-year transition, 2021-2030	1,078*
3) Average annual job loss over 10-year production decline *(= row 2/10)*	108
4) Number of workers reaching 65 over 2021-2030 (=row 1 x % of workers 54 and over in 2019)	1,977 *(21.4 % of all workers)*
5) Number of workers per year reaching 65 during 10-year transition period (=row 4/10)	198
6) Number of workers per year retiring voluntarily	158 *(80% of 65+ workers**)*
7) Number of workers requiring re-employment (= row 3 – row 6)	0

Source: Table 6.1.

Note: *Job losses includes 605 construction jobs in the natural gas distribution industry that will phase out in phase 1 because the industry will contract by 75 percent during 2031-2050. **The 80 percent retirement rate for workers over 65 is derived from U.S. Bureau of Labor Statistics data: https://www.bls.gov/cps/cpsaat03.htm. According to these BLS data, 20 percent of 65+ year-olds remain in the workforce.

We begin in Table 6.16 with the total fossil fuel-based industry workforce of 9,239 workers. Based on the respective contraction rates for the oil and construction activity in natural gas, we estimate that the total job contraction will amount to 1,078 workers over 2021 – 2030 Assuming a steady rate of contraction, this amounts to an average rate of job losses of 108 per year.

We then estimate that 1,977 workers employed in the industry will reach the age of 65 over 2021 – 2030, which averages to 198 workers per year. Of this total, we assume that 80 percent of these workers will retire voluntarily once they reach age 65. This amounts to 158 workers in San Diego County's fossil fuel-based industries retiring voluntarily per year.
Thus, according to our estimates, 108 jobs per year will be lost in the San Diego region due to the contraction of fossil fuel consumption, while 158 workers per year will voluntarily retire from the industry. In total, therefore, San Diego should not experience any job displacements through 2030 as a result of the region's commitment to move onto a zero-emissions trajectory

through 2030. In other words, through 2030, no workers in the county that are currently employed in any of its fossil fuel-based industries will require reemployment.

Planning a Just Transition Program

In working from the ERR model for transitioning San Diego County into a zero-emissions economy by 2050, we have seen that the fossil fuel industry in the county will not experience job displacements through 2030. However, job displacements will certainly result between 2031 – 2050, as oil consumption in the county falls by 95 percent relative to the present level and natural gas consumption falls by 75 percent. As such, as one critical part of the project of advancing the transition to a zero-emissions economy by 2050, San Diego county and local governments should begin now to develop a viable set of just transition policies for the workers in the community who will experience job displacement between 2031 – 2050.

In previous work, we have outlined just transition programs that include five policy measures (e.g. Pollin et al. 2020).[1] These are:

1. ***Pension guarantees*** for all workers in fossil fuel-based industries, especially those workers who will be retiring voluntarily over the transition period.
2. ***Reemployment guarantees*** for all displaced workers.
3. ***Wage insurance*** for all displaced workers. One approach is to guarantee 3 years of total compensation at levels the workers had been receiving in their fossil fuel jobs.
4. ***Retraining support.*** This could include 2 years of retraining support for workers who required this in their new areas of employment.[xlvi]
5. ***Relocation support.*** This should be sufficient to cover full moving expenses for all workers who are forced to relocate.

It would be beneficial for the San Diego region's governments to begin now to consider the most effective ways through which to implement this or some comparable set of measures. To begin this process now will greatly increase the likelihood that the region will succeed in building a zero-emissions economy, while also preventing large numbers of community members from experiencing major economic losses as the transition program advances.

[xlvi] The County has retained Inclusive Economics to develop a comprehensive and coordinated regional strategy to address the workforce needs resulting from labor-market changes related to the region's Decarbonization Framework. The report will be jointly authored by Dr. Carol Zabin and Betony Jones and modelled after California's Jobs and Climate Action plan that provide recommendations on how to support San Diego's workforce as the region transitions to a carbon-neutral economy.

SUPPLEMENTAL NOTE: Employment Impacts of Geothermal Energy Projects for Imperial County

Chapter 2 of this project on "Geospatial Analysis of Renewable Energy Production," describes a project to develop geothermal energy production sites in Imperial County. The authors write:

> Five geothermal sites are identified in Imperial County with generation of 10,680 GWh of electricity (seen as green points in Figure 2.8). This analysis assumes these plants become fully operational by 2030 and supply the remaining capacity to San Diego after satisfying Imperial's electricity demand (p. 6-7).

In this note, we estimate the employment impacts of developing this geothermal energy project. Because the project will be developed in Imperial County rather than San Diego County, we estimate in this case the employment effects throughout Southern California.

Our estimate is that this project will generate about 1,900 jobs per year throughout Southern California over the course of the 10-year period to complete the work.

We derive this result as follows:

1. Chapter 2 states that the aim of the project will be to generate 10,680 GWh of electricity capacity.
2. This level of electricity generation is equal to 0.04 quadrillion BTUs ("Q-BTUs" or "quads" of energy).
3. In its February 2021 report on levelized costs of energy generation, the U.S. Energy Information Agency estimates the lump sum capital expenditures to develop one Q-BTU of geothermal generating capacity is $78 billion.[xlvii]
4. This, to develop 0.04 Q-BTUs of geothermal electricity generating capacity will cost about $3.1 billion (i.e. $78 billion x 0.04 = $3.1 billion).
5. From these figures, we document in Table 6.17 our estimate of job creation throughout Southern California through from building this level of geothermal capacity in Imperial County. As Table 6.17 shows, we estimate that this project will produce as an average over 2021 – 2030 810 direct jobs, 465 indirect jobs and 589 induced jobs. This amounts to 1,275 direct and indirect jobs and 1,864 jobs in total.

[xlvii] EIA study is here: https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf. See Pollin et al. (2021)[3], p. 27 for conversion of EIA capital costs in overall levelized cost framework into lump sum capital expenditures.

Table 6.17. Job Creation in Southern California through Geothermal Energy Projects in Imperial County.

	1. Job Creation per $1 million	2. Job creation through $3.1 billion in spending	3. Job creation per year over 10-year period, 2021 – 2030 *(= column 2/10)*
Direct Jobs	2.6	8,100	810
Indirect Jobs	1.5	4,650	465
Induced Jobs	1.9	5,890	589
Total Jobs	6.0	18,640	1,864

Sources: IMPLAN 3.0.; citations in text.

Appendix 6.A.1: Estimating San Diego County-Specific Employment

The ERR model is for Southern California includes 13 counties in addition to San Diego County. These 13 additional counties are: Ventura; Fresno; Mono; San Bernardino; Riverside; Santa Barbara; Kings; Los Angeles; Orange; Kern; Tulare; Imperial; and Inyo. In order to generate estimates of employment impacts *within San Diego County itself*, we therefore need to work with some assumptions in defining the proportionate level of activity in San Diego County relative to all 14 counties constituting Southern California in the EER model.

As of 2019, San Diego County's total economic output is $417.9 billion. This amounts to about 14.6 percent of the total level of activity throughout Southern California, which is $2.87 trillion. In reviewing the evidence from the EER model as well as the detailed input-output data for the activities in this model, we conclude that a reasonable assumption for estimating employment creation in San Diego County is a straightforward one. That is, *we estimate that the level of employment creation in San Diego County will amount to 15 percent of the employment creation in Southern California overall through the EER model.* In other words, employment creation in San Diego County generated by the activities in the EER model will be proportional to the ratio of total output in San Diego County relative to Southern California, i.e. as with San Diego County's output at roughly 15 percent of that for Southern California.

One could certainly develop more detailed assumptions that would relate to various specific features of the EER model. But incorporating a more highly specified set of assumptions is not likely to generate more accurate employment estimates. Here are the main considerations through which we reached this conclusion:

Demand-Side and Supply-Side Activities in ERR Model

The EER model consists of two sets of activities: demand-side purchases and supply-side investments. We consider these two sets of activities separately.

Demand-side purchases. The demand-side purchases include everything that consumers in Southern California purchase that will provide energy services at reduced rates of energy consumption. These would include purchases of electric vehicles, electric heat pumps and other HVAC equipment, appliances, and refrigeration equipment. EER modeling estimates that these costs will be between $55.0 and $74.0 billion per year in the Southern California zone, with an annual average of $66.9 billion.

With these demand-side purchases, it is reasonable to assume that San Diego County's increased purchases will not be constrained by any shortages that would be specific to the county itself. Shortages of specific products could well emerge as the level of clean energy expenditures in the region grows rapidly. But there is no reason to assume that any such shortages are likely to emerge specifically in San Diego County, as opposed to the broader Southern California region. Thus, we assume that roughly 15% of Southern California's demand-side purchases take place in San Diego: $9.9 billion dollars per year, on average.

Supply-side investments. The supply-side investments include everything that contributes to supplying a zero-emissions economy—e.g. architectural, engineering and related services, communication and energy wire manufacturing, turbine manufacturing, residential construction, scientific research and development, as well as ongoing investments in the county's fossil fuel-based industries. EER modeling estimates that these costs will be between $33.1 and $35.0 billion per year in the Southern California zone, with an annual average of $34.1 billion.

Relative to the demand-side investments, it is less straightforward with the supply-side investments to assume that the San Diego share of total Southern California activity will remain proportionate to the Southern California figure. The major consideration that could produce disproportionately slower growth with any given investment activity within the county would be if this investment activity produces significant supply constraints to growth within the county as clean energy activities scale up throughout the region. For example, the installation of solar panels in San Diego County might be disproportionately low because of land-use issues. A disproportionately large share of solar installations might then take place in, say, Riverside County. The solar-generated electricity could then be imported from Riverside to San Diego County. Thus, we assume that roughly 15% of Southern California's supply-side investments take place in San Diego: $5.1 billion dollars per year, on average.

In fact, in examining the current profile of supply-side investments in San Diego County within the ERR model, it does not appear that there should be significant supply constraints specific to San Diego County as clean energy investments expand in the region. At present, there are only 7 supply-side activities in the EER model in which San Diego County's current share is over 25 percent of all Southern California activity—i.e. significantly greater than San Diego's current share of overall Southern California output, at 15 percent. These activities are: natural gas distribution; sugar cane mills and refining; turbine and turbine generator set units manufacturing; capacitator and other inductor manufacturing; other communication and energy wire manufacturing; all other miscellaneous electrical equipment and component manufacturing; and scientific research and development services. Of these 7 activities, there is only one in which this activity accounts for more than 2 percent of all of San Diego's economic activity. That is scientific research and development services, which currently account for nearly 9 percent of all of San Diego County's total output.

It is not likely that San Diego County would face supply constraints in expanding its scientific research and development services. This activity will not generate significant land-use demands. It will also not produce any significant negative environmental impacts. As such, it is reasonable to conclude that San Diego County is well-positioned to absorb a substantial absolute increase in scientific research activity within the county. Indeed, it is almost certain that the county will welcome a major expansion of activity in this sector.

Overall, again, it therefore seems reasonable to work with a straightforward assumption that San Diego County's share of supply-side activities in the EER model will be maintained, as with the demand-side activities, at its current share of aggregate Southern California output. We therefore assume that the share of both the demand- and supply-side activities within the ERR model for Southern California will generate employment in San Diego County that is equal to 15 percent of employment creation in Southern California.

An important caveat to this is that the regional level costs—both demand and supply-side—reported by the EER model are subject to significant uncertainty. These models are meant to estimate costs over broad geographic areas, and do not produce detailed outlines of the geographic distribution of these costs in sub-regions. The distribution of costs depend on many factors—including fuel availability, sequestration costs, and economic and population trends—which are very difficult to estimate over time at a very high spatial resolution. For this reason, we have treated EER model cost estimates for zones (like Southern California) as broad approximations.

Works Cited

1. Pollin, Robert, Jeannette Wicks-Lim and Shouvik Chakraborty (2020) "Industrial Policy, Employment and Just Transition," Chapter 3 in *America's Zero Carbon Action Plan*, Sustainable Development Solutions Network, https://irp-cdn.multiscreensite.com/6f2c9f57/files/uploaded/zero-carbon-action-plan-ch-03.pdf
2. Pollin, Robert, Heidi Garrett-Peltier, James Heintz, and Shouvik Chakraborty (2015) *Global Green Growth: Clean Energy Industrial Investments and Expanding Job Opportunities*, United Nations Industrial Development Organization and Global Green Growth Institute, https://www.unido.org/sites/default/files/2015-05/GLOBAL_GREEN_GROWTH_REPORT_vol1_final_0.pdf
3. Pollin, Robert, Jeannette Wicks-Lim, Shouvik Chakraborty, Caitlin Kline, and Gregor Semieniuk (2021) *A Program for Economic Recovery and Clean Energy Transition in California*, Political Economy Research Institute, https://peri.umass.edu/economists/gregor123/item/1466-a-program-for-economic-recovery-and-clean-energy-transition-in-california

7. Key Policy Considerations for the San Diego Region

Joseph Bettles, UC San Diego
Gordon C. McCord, UC San Diego
David Victor, UC San Diego

Key Takeaways

- Reduction of GHG emissions across the region is a coordination problem for cities and agencies that must act together to address region-wide emissions. The need for collective action is heightened due to conditions of uncertainty around the best course of action and implementation strategies. For solutions to achieve necessary scale will require mechanisms to incentivize sharing of information, capacity, and technology between jurisdictions.
- Each sector analyzed by the RDF has near-term actions that will be worthwhile regardless of how longer-term uncertainty resolves itself. These near-term "no-regret" or "little regret" policies should be prioritized.
- This chapter proposes region-wide institutional governance for decarbonization that incentivizes experimentation and involves those on the front lines in an evolving structure that can adapt to changing technological and political realities.
- For San Diego to have a measurable impact on global emissions it should seek to generate followership among other regions and upscale durable innovations that can be expanded and replicated.

7.1 Introduction

The governing bodies of the San Diego region – including 18 cities, public agencies, and the County of San Diego – face the unprecedented challenge of decarbonization by midcentury or earlier. This will require coordination and a clear vision for near- and long-term policy actions on the electric sector, land use, buildings, and transportation. The scientific modeling of the Regional Decarbonization Framework (RDF) offers least-cost technically feasible pathways and near-term strategies to lower emissions and set the region on a path to decarbonization. However, even the best models are unable to perfectly identify the best course of action ex-ante, given uncertainties around technologies, resources, and future socio-political realities. Instead, the RDF provides a scientifically sound framework to inform policy debate, as well as to outline high-confidence near-term policy solutions and inform long-term planning.

The central challenge for the San Diego region is that even as it focuses on deep decarbonization, local governments have a limited degree of influence, with broader indirect influence over the full suite of actions needed. Therefore, successful deep decarbonization in the region will first require the identification of needed actions and institutions that can bring about change – with the County government playing a key orchestrating role in working with the other players in the region as well as at the state and federal level. This chapter outlines an institutional structure that can facilitate continued collaborative action between government officials, planning bodies, regulators, industry stakeholders, and academics. At this early stage of decarbonization, many of the needed actions are unknown and unknowable, therefore, collaborative action will require an approach to policy that relies on experiment and rapid learning. Building on the science of the RDF, an institutional structure and processes that facilitate the implementation of best practices will produce durable solutions. Finally, as San Diego represents a tiny fraction of global emissions, we offer strategies for San Diego's efforts to have a broader impact on climate policy in other regions of the country and beyond.

7.2 The Need for Coordination on Decarbonization within the San Diego region

The Local Region as an Agent of Change

It is widely accepted that local governments are at the front lines of both climate change adaptation and mitigation efforts.[1–4] In the absence of meaningful international action on climate change, cities are stepping up as leaders to coordinate on the reduction of greenhouse gas (GHG) emissions.[5] Coordination among neighboring cities can increase the effectiveness of cities through the diffusion of best practices as well as increased leverage and capacity from combined resources.[6]

The government of San Diego County is a natural coordinating body in the San Diego region. The County operates in a privileged position in climate governance with a combination of proximity to the local context and connection to state and federal resources.[7] The governing body, the County Board of Supervisors, represents all areas of the region and holds land use planning authority in the unincorporated areas of the County. In addition, the County receives federal and state funds for health, infrastructure, and more recently, economic stimulus.[8].

While the region faces significant challenges in the coordination of 18 cities and several key agencies, given the right incentives, the fragmentation within the region can facilitate competitive pressure that increases the likelihood of policy innovation among the many cities.[9] For example, the City of San Diego was the first city in the region to develop a Climate Action Plan in 2015. In the years following, nearly all other cities adopted climate actions plans (SANDAG 2021). Smaller cities can attract attention for bold climate action, such as the natural gas ban by the City of Encinitas in 2021.[10] The distinct advantages of proximity, control of state and federal resources, and competitive pressure provide the opportunity for coordinating efforts by the County to have a meaningful impact on regional GHG emissions.

The Need for Collective Action and Coordination

Reduction of GHG emissions across the region is a collective action problem - it requires joint action by many actors that, in the absence of incentives, would choose not to contribute. In addition, there is a coordination problem for cities and agencies that must act together to address region-wide emissions. While some sources of emissions can be ascribed to a specific geographic area (e.g., methane from solid waste), the three largest sources of emissions in San Diego: light-duty vehicles (37%), electricity (23%), and natural gas in buildings (8%)[11] cross municipal boundaries. Addressing these emissions will require coordination across local governments and public agencies. The need for collective action is heightened due to conditions of uncertainty around the best course of action and implementation strategies. For solutions to achieve necessary scale will require mechanisms to incentivize sharing of information, capacity, and technology between jurisdictions.

Improving the strategies for coordination can provide additional benefits for the region. Working as a region can achieve economies of scale,[12] diffusion of successful innovations,[13] and more equitable distribution of resources. For example, coordination between local governments in Southern California and the state of California on EV charging stations has led to an even distribution across census tracts with different income levels.[14] An institutional structure that can achieve coordination and collective action will require mechanisms that incentivize public and private actors to coordinate on new solutions and disincentivize inaction.[15]

The Regional Players in San Diego

Within the San Diego region there are 18 cities, and several agencies and government offices relevant to decarbonization. The largest regional agency, and most relevant for decarbonization, is the Municipal Planning Organization (MPO), the San Diego Association of Governments (SANDAG). The MPO is designed for regional coordination around transportation and land use planning. Under the Regional Planning Committee, SANDAG has established seven working groups:

- Regional Planning Technical Working Group
- Environmental Mitigation Program Working Group
- Public Health Stakeholders Group,
- Military Working Group
- Shoreline Preservation Working Group
- Energy Working Group
- Regional Housing Working Group

The seven working groups may offer a starting point in the development of an institutional structure to increase coordination on GHG reduction. Outside of government, San Diego has several private and academic networks that coordinate efforts outside of government on climate-related initiatives. Existing networks will be an important resource for structures that seek to draw on local expertise.

The Role of San Diego County Government

The County has several areas of direct influence in decarbonization as well as indirect influence as a regional governing body with representation from all parts of the region. The recent decision to join San Diego Community Power (SDCP), provides the County with influence in the development and procurement of electricity for the region.[16] In addition, the County is a voting member of several important agencies and boards with authority over transit, water, air quality, and the airport. In Figure 7.1, the County's role in decarbonization is shown in the regional context. While it lacks direct authority over cities, county-wide representation positions the County as a leader of decarbonization in the region.

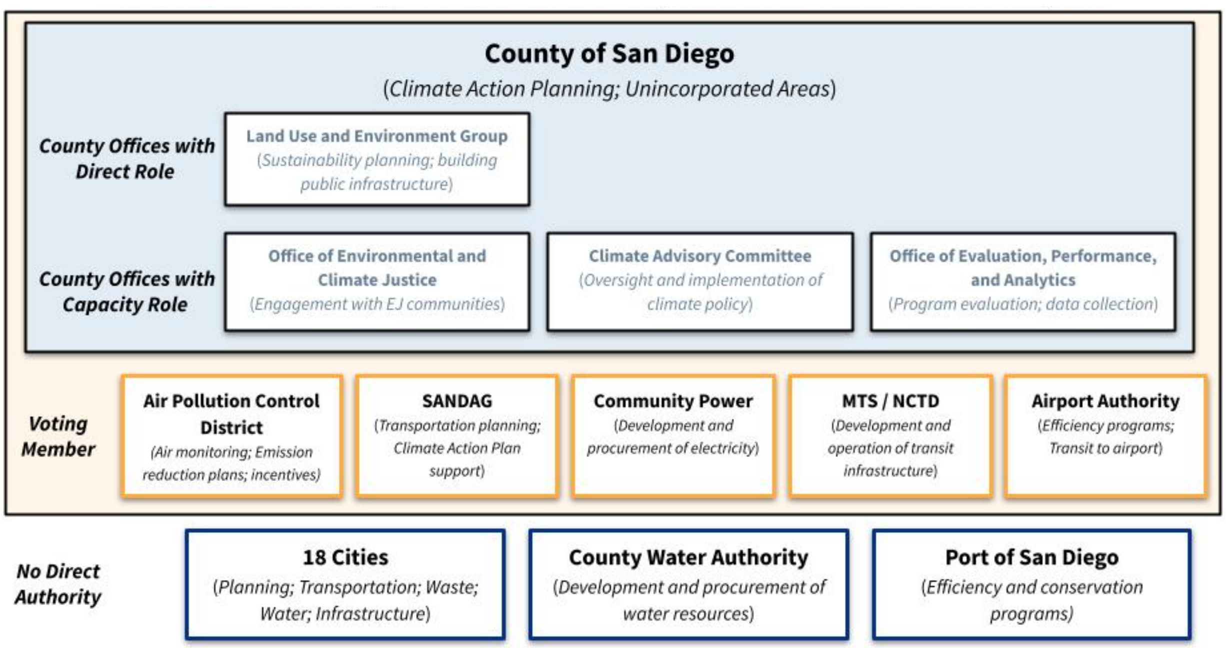


Figure 7.1. Role of the County of San Diego in the Regional Decarbonization Context

Focus Group Feedback[xlviii]

On the week of August 23rd, 2021, focus group sessions were held on the topics of buildings, energy, transportation, and land use. The feedback sessions lasted approximately one and a half hours and included stakeholders from industry, civil society, and academia. The final question posed to all focus groups solicited feedback on an institutional framework that could support implementation. The groups were asked, "considering the range of stakeholders in this sector -- including public agencies, advocates, energy providers, and others -- what would a collaborative effort look like to create and implement the framework?". To identify key themes across focus groups, the responses are aggregated in Figure 7.2 below. We summarize the feedback into three key actions 1) establish goals, 2) organize players, and 3) engage and inform. In the development of regional governance for decarbonization, we integrate these recommendations.

Needed Action for Coordination	Key Messages	Key Actions
- Region-wide plan with publically available data - Measurement of County efforts	Set Clear Goals and Measure Progress	Establish Goals
- Identify a list of shovel-ready projects - Inventory the projects that are being worked on throughout the County	Elevate Priorities	
- Note that SANDAG working groups already bring together public, private, advocacy groups throughout the region - Inventory all existing networks (private, non-profit, public)	Utilize Existing Networks	Organize Players
- More coordination among gov agencies including CCAs - More positions in charge of implementation and coordination within cities and agencies	Coordinate Government Agencies	
- Communication, education, and outreach of climate plans - Communicate to CBOs / schools and collaborate on goal setting - Communicate the costs and benefits of the transition	Public Engagement	Engage and Inform
- Bring private sector into the discussions - Create a platform for coordinated leadership of the private sector - Collaborate with civil society organizations working on climate	Engage with Outside Organizations	

Figure 7.2. Aggregated Focus Groups Response on How to Implement the RDF.

Relevant California State Legislation

In 2021 the California State Legislature considered Assembly Bill 897[xlix]. The proposed legislation would have created networks of local governments overseen by the Governor's Office of Planning and Research eligible for funding. While the bill did not pass, the proposal

[xlviii] The focus groups are discussed in more detail in Appendix B.

[xlix] AB 897l, 2021: https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220AB897

indicates a growing recognition by state leaders of the need for more coordination within regions on climate governance.

In the recent $15 billion climate package[l] signed by Governor Newsom on September 2021, $20 million is dedicated for "Regional Climate Collaboratives" (RCC) for which technical assistance grants will be distributed through the Strategic Growth Council (SGC). The SGC is responsible for funding climate collaboratives, and SB 107[li] will add to existing funding. SGC funded collaboratives are community driven, and partner with public agencies, therefore, it would need to exist outside the County[lii]. This will be an important development to track for potential state resources to fund climate initiatives in the San Diego region.

County of San Diego's Leverage on Decarbonization within the Four Sectors

To inform the institutional structure and processes, we provide an overview of key decarbonization actions, areas of uncertainty, and County leverage points from each of the four sectors: land use, buildings, transportation, electric sector. We define leverage as direct or significant influence of the County over actions to achieve deep decarbonization. The overview in Table 7.1 provides the basis of several takeaways that are used to inform an institutional structure to support implementation among a wide range of heterogeneous actors.

l Governor Newsome, 2021: https://www.gov.ca.gov/2021/09/23/governor-newsom-signs-climate-action-bills-outlines-historic-15-billion-package-to-tackle-the-climate-crisis-and-protect-vulnerable-communities/
li SB 1072, 2018: https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB1072
lii SGC Community and Technical Assistance Programs, 2021. https://sgc.ca.gov/programs/cace/resources/

Table 7.1. Key Actions and Areas of Leverage

	Land Use	Buildings	Transportation	Power
Key Emission Sources	Disturbance of intact ecosystems (e.g., wildfire, sea-level rise, development)	Residential water heating. Space heating/cooling Process energy	Internal combustion engine emissions from light- and heavy-duty vehicles and freight	Electricity generated from natural gas power plants
Key Decarbonization Actions	Protect existing carbon pools to avoid releasing stored sinks of CO2, prioritizing intact, native ecosystems Manage existing ecosystems to increase carbon sequestration as well as to mitigate wildfires and storm surge damage through forest, chaparral, and wetland management/restoration. Promote “climate farming” to change agricultural lands from sources into sinks and to manage agricultural methane emissions	Increased adoption of electrification of space and water heating Geographically targeted electrification (e.g., in neighborhood clusters) End expansion of the gas utility system to lower the risk of stranded assets. Building shell improvements to reduce electric system peaks and manage system costs Improved data gathering is a low-cost, foundational action for future policy development	Reduce demand for travel Shifting to EV for LDV, HDV, and freight Siting charging infrastructure Multi-modal oriented development where assets are already present Accelerate replacement rates Engage with vulnerable communities	San Diego County has sufficient solar and wind resource potential to transition electricity to 100% of the estimated demand with renewable resources inside the County, while the Central Case from the overall model retains firm power gas infrastructure to keep costs low. Neighboring Imperial County has significant solar and geothermal beyond internal population demands CAISO estimates necessary transmission network upgrades for San Diego - Imperial - Baja - Arizona to be $3.9 billion and will take decades to complete
Areas of Uncertainty	There is a high degree of uncertainty around the benefits of reforestation and afforestation It is uncertain the degree to which natural climate solutions are a reliable source of negative emissions	The long-term best extent of electrification is uncertain (70%? 85%? 100%?), but not relevant for near-term action. Uncertain performance/results from new policy levers (at local, state, federal levels) Future cost, availability, and demand for low-carbon gas is uncertain; this suggests it may need to be saved for hardest to decarbonize sectors.	Alternative fuels Resilience in the face of supply disruptions The political feasibility of mandating shifts The degree of flexible charging and the feasibility of vehicle to grid (V2G) systems.	Ability to upgrade the capacity of the transmission system to meet demands Social acceptability of large utility-scale projects Storage and firm power The degree to which Mexico will provide a source of renewable electricity inputs

County Policy Leverage	Purchase land for permanent conservation Education/training on increasing sequestration for owners of privately owned land “Carbon farmer” certification program that would train farmers on how to increase the sequestration on farmland Incentives for farmers and landowners to adopt carbon sequestration practices	Building energy use disclosure policies that enable building performance standards and/or energy actions Lead by example with public buildings Rental property performance regulations Customer service/resident guidance/coaching Technical assistance and commercial guidance Building energy codes/reach codes (covering new construction and major renovations) – should be “electrification ready” at least, if not stronger Reducing embodied carbon in buildings through zoning or building codes could complement policies focused on operational carbon Leverage the existing Regional Energy Network (REN) and community choice aggregation (CCA) platform to promote building electrification—including outreach, engagement, and enrollment in building decarbonization initiatives Use of various funding and finance mechanisms to promote building electrification Building operator certification programs Data gathering on the pace of decarbonization actions along with annual benchmarks for progress, and track/report against benchmarks	Align affordable housing with employment centers Roadway improvements for biking/walking Remove parking requirements Charging infrastructure in public ROW and building improvements Incentives for clean vehicle purchase Pilot programs Flexible charging and V2G pilot projects with County fleets	Power purchase agreements through SD Community Power (CCA) Approve new projects that come before the board and identify public facilities and lands where renewables can be sited Work with private developers to identify suitable sites for renewable energy and engage with local communities in the process

Takeaway 1: Sector divisions. Regional governance should be broken down into sectors to ensure solutions respond to distinct technological, economic, and political needs.

The first takeaway that emerges from Table 7.1 is that each sector requires a distinct set of policy actions that can benefit from specialization. Sectors range from having relatively few emissions sources (electricity), to highly diffuse sources with a wide range of incumbent technologies (buildings). Some policy actions are geared toward supply (electricity) while others require a focus on demand (transportation). Aligning a governance structure with sectors will allow for tailored policy solutions as well seamless integration of expertise from industry and academia.

Takeaway 2: Uncertainty. Regional governance should be designed for uncertainty.

The second observation is that each sector has near-term actions that will be worthwhile regardless of how longer-term uncertainty resolves itself. These near-term "no-regret" or "little regret" policies should be prioritized. Long-term actions include degrees of uncertainty. To what degree and how fast will electrification take place? What will be the role of low- and zero-carbon fuels? How reliable are intact ecosystems as a source of negative emissions? Beyond the near-term, we are unable to answer these questions with a high degree of confidence. Therefore, an institutional framework that is structured to achieve decarbonization will require flexibility and the ability to respond to changing conditions. Further, uncertainty should be addressed through experimentation among the players to arrive at new solutions and greater levels of confidence on measurement of outcomes.

Takeaway 3: Coordination. A wide range of actions is necessary that involves the private sector and government officials from multiple levels and jurisdictions.

To achieve necessary reductions in emissions within each sector, coordination between a wide range of stakeholders is required. For example, transportation and buildings require electrification of complementary technologies that will require labor, infrastructure, capital, and policy to work together. Therefore, it will be beneficial for businesses and institutions with direct involvement in the decarbonization of each sector to be represented in the framework, both as a matter of achieving buy-in but also to respond and adapt to the needs of those on the frontlines.

Takeaway 4: Innovation. Many of the technological and distribution systems are in early states of readiness and require investment and further innovation to reach maturity as a policy solution.

Several of the pathways to decarbonization depend upon technologies that have not reached wide scale distribution including long-term battery storage, low-carbon fuels, and heat pumps. While regional scale investments are not likely to have dramatic impacts in technological readiness, needed innovation can occur for deployment and policy. For example, vehicle to grid (V2G) systems is an emerging technology that can reduce the need for battery storage of renewable electricity.[17] UC San Diego is home to a California Energy Commission pilot project in partnership with local startup Nuuve to study V2G implementation.[18] Cities within San Diego could achieve greater innovation in the implementation of V2G systems through pilot projects at the municipal scale. This could have spillover effects on the development of local businesses that specialize in V2G.

Takeaway 5: Incentives. Incentives will be important to reward collective action and disincentive inaction.

Incentives are required at multiple levels to achieve decarbonization. At the individual level, incentives can increase demand for goods and services including heat pumps, EVs, and building shell improvements. At the local government level, incentives can lead to greater cooperation from cities on policies, regulations, and necessary infrastructure.

7.3 Case Studies for Regional Coordination

The proposal for an institutional framework for San Diego is also informed by case studies of collaborations between cities on climate policy. We outline three examples of coordination between cities.

Effective Local Leadership on EV Infrastructure in San Diego

An existing collaborative institution in San Diego, *Accelerate to Zero Emissions*[liii] together governments, agencies, and industry around the development of a strategy to achieve zero emissions in transportation. The structure shown in Figure 7.3 includes ground-level industry groups that work alongside government officials to oversee and advise the creation of a strategic planning process. Importantly, the strategy is intended to evolve over time with input from public and private organizations. The institution is relatively new, and strategies have yet to be implemented. However, the structure is an innovative approach to collaboration that exists within San Diego and can inform structures for decarbonization more broadly.

[liii] Accelerate to Zero Emissions (A2Z), San Diego. http://a2zsandiego.com/static/zero/

Modeling as the Foundation of Policy Action in Massachusetts Decarbonization Roadmap

Governor Charlie Baker through the Executive Office of Energy and Environmental Affairs (EEA) commissioned a Decarbonization Roadmap Study with a "comprehensive understanding of the necessary strategies and transitions in the near- and long-term to achieve Net-Zero by 2050 using best-available science and research methodology".[19(p. 7)] The roadmap was created as the scientific foundation for GHG targets and the state's policy action plan. In addition to the roadmap report, the Office oversaw the creation of an institutional structure that included an implementation advisory committee with stakeholders and a technical steering committee with experts across fields. The evidence-based models developed for the Roadmap became a coordinating mechanism that anchored climate efforts around technically feasible solutions.

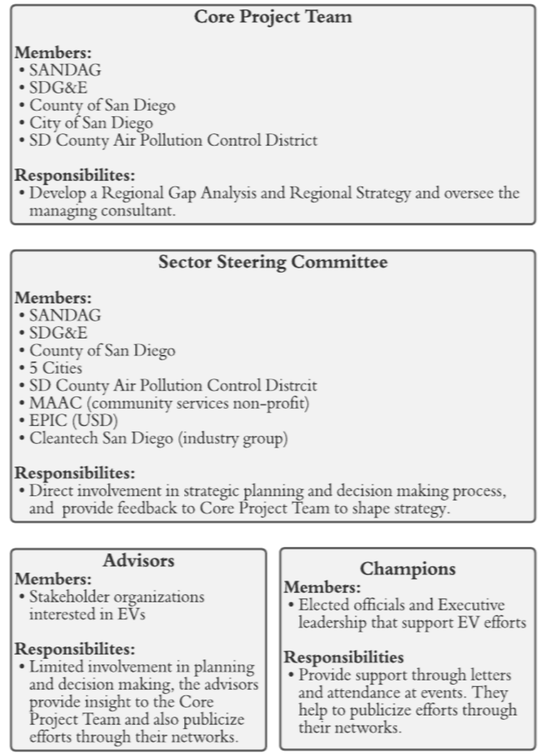


Figure 7.3. "A20" Organizational Structure

Bi-directional Governance in German Climate Change Management

In a study of cities as leaders of climate policy in the EU, Kern[5] identifies several lessons that could prove useful to San Diego. Kern advocates an embedded upscaling approach in which decision-making takes place within cities under the guidance of a larger network. Kern highlights the case study of the German Climate Change Management (KPL) in which German states create goals for decarbonization and municipalities decide on implementation strategies that are feasible within their context. States provides funding based on adherence to the goals as well as the financial need of the municipality. Kern notes that a co-benefit of this approach is that city staff become experts on decarbonization which has led to a knowledge-sharing network across cities.

7.4 Institutional Structure Built for Uncertainty and Limited Degree of Influence

Uncertainty underpins all forecasted risks of climate change. Further, the capacity to accurately measure risks as well as technologies and policy interventions are subject to constant evolution.[20] In this environment, even empirically based interventions and the finest tuned forecasts are subject to uncertainty over time. Failures to accurately predict energy transitions were evident in forecasts that overlooked the shale gas boom,[21] as well as unforeseen rapid decreases in costs of renewables and storage technologies.[22] Rather than abandon forecasts altogether, we find that the common aphorism, "all models are wrong, but some are useful" is an appropriate perspective to have when thinking about modeled pathways for decarbonization in the region.

In the four sectors of the RDF, we find uncertainty for all projected pathways. For land use, there is uncertainty due to a lack of empirical evidence on the reliability and magnitude of negative emissions from natural climate solutions. For buildings, uncertainty exists for the cost and availability of low-carbon fuels. For transportation, the feasibility of mandates and the ability to manage EV charging are subject to high degrees of uncertainty. Finally, in the electric sector, there is uncertainty around complementary storage and transmission technologies. Beyond uncertainties identified in the RDF are the countless unknowns due to environmental, technological, social, economic, and political shocks, acutely illustrated by the COVID-19 pandemic. In addition to uncertainty inherent in the pathways, the County's limited sphere of influence creates the need for mechanisms that increase coordination among players in the region.

Together, limited degree of influence and lack of certainty create the need for the County to play a role in orchestrating an institutional structure that can incentivize experimentation and learning among the various jurisdictions operating in a rapidly changing technological and political landscape. For this, we turn to experimentalist governance and the lessons of successful climate institutions illuminated by Victor and Sabel.[15] The core tenets of experimentalist governance are:

- Incentivize experimentation with investments in new solutions, away from the status quo
- Encourage ground-level innovations that become universal standards
- Expect false starts and overreach that will inform changes to structures and processes over time

Embedding these tenets into a structure for the region can allow for policies to adjust to a changing landscape, or, in some cases, to create the necessary alternatives. For example, there is a high degree of uncertainty as to the best technology, policies, and operation of EV charging to balance electricity loads for a grid with high renewable energy penetration. Rather than deciding on a single solution for the region or, worse, doing nothing due to uncertainty, San Diego can fund pilot projects similar to the V2G pilot at UC San Diego at the municipal level. Results from pilot programs can inform policy for the remaining cities and contribute valuable knowledge to an important global challenge for decarbonization.

7.5 Proposal for Institutional Structure

A Framework for Regional Governance

The implementation of a region-wide decarbonization framework will require a structure that is able to respond to the needs of those on the front lines as well as evolving technological and political realities. We propose the outline for regional governance that is designed to adapt to changing conditions over time. Experimentalist governance[liv], along with key findings of the four sectors, core themes from focus groups, and case studies inform our proposal for regional governance of decarbonization in San Diego. In Figure 7.4 we outline recommendations for organization, incentives, and mechanisms as a starting point for regional governance, followed by further discussion of the components.

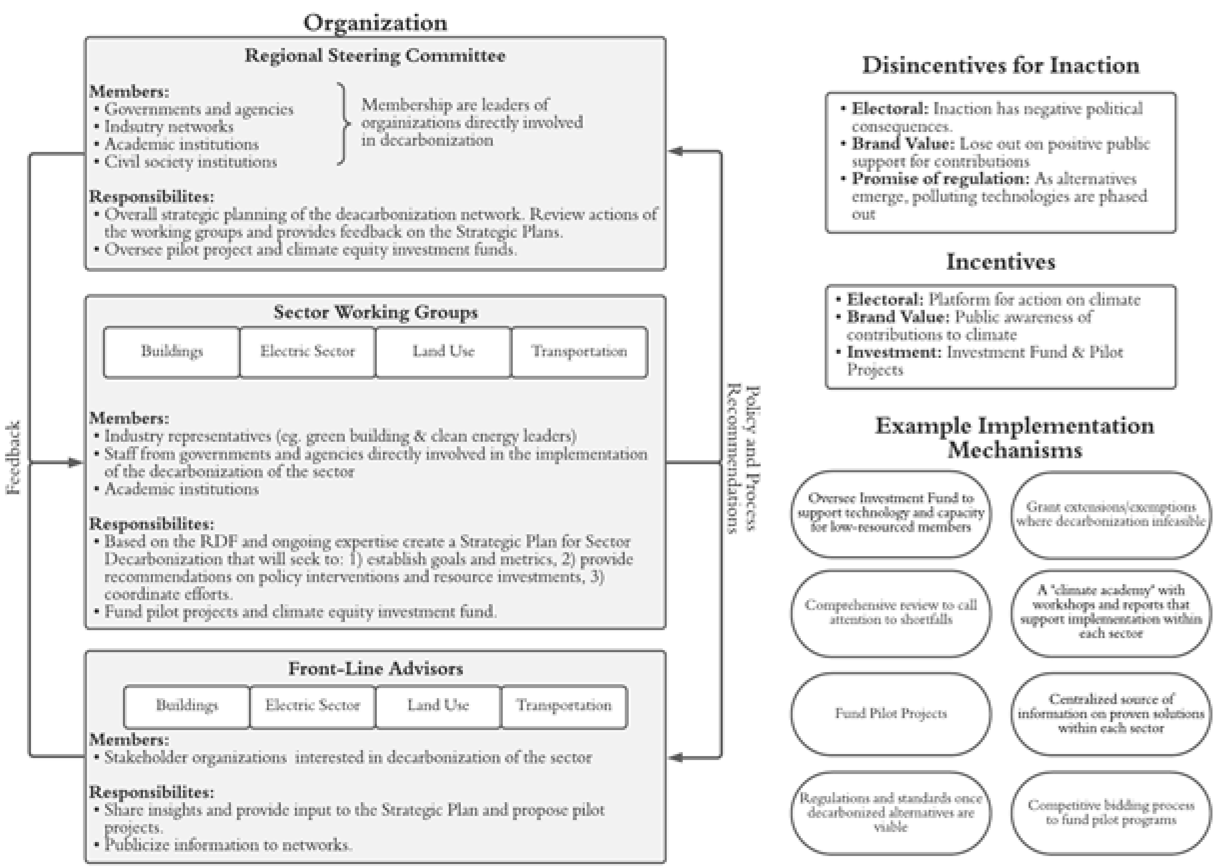


Figure 7.4. Proposed Regional Governance of Decarbonization.

[liv] The principle of Experimentation is drawn from Victor and Sabel (2020) - cities in the San Diego Region can act as laboratories for policy innovation that is standardized and entrenched over time.

Regional Steering Committee: The core governing body of the overall governance structure, the Steering Committee is made up of members in government, industry, academia, and civil society institutions and is responsible for the overall strategic planning of the network. It is the key oversight body that can institute changes to governance processes and representation in sector groups.

Sector Working Groups: Divided into the four key sectors, the Working Groups oversee strategic plans for each sector based on RDF modeling and ongoing industry, academic, and government expertise. In addition, if funding opportunities for pilot programs and investment funds become available, the sector working groups could decide on the beneficiaries and oversee implementation. As discussed above, the working groups in SANDAG may serve as existing bodies suitable to this role.

Front-Line Advisors: The advisors are public and private players in the region responsible for the implementation of decarbonization measures. In the event of available funding for pilot programs, advisors could propose projects, while also providing feedback on outcomes. Further, the front liners are a key source of feedback on policy and should provide a source of peer review to the Sector Working Groups.

Incentives: There are direct forms of incentives such as funding pilot projects, as well as indirect incentives for elected officials and businesses to be seen as part of collaborative efforts on climate change. Laggards will be drawn in due to incentives for participants involved in successful innovations.

Mechanisms for Learning and Collaboration: The list of mechanisms provided in the figure is by no means exhaustive, nor are they meant to be prescriptive. They are intended to provide a starting point for the kinds of actions a regional governance organization can take to promote and incentivize learning and collaboration. They center around key actions of funding pilot projects, promoting learning and information diffusion, measurement, review, and stimulating competition among members to innovate.

Conference of Governments

A key lesson that emerges from the literature is the importance of recognizing climate leaders and increasing awareness of successful policy interventions.[5,7,23] A San Diego Conference of Governments (COG), modeled on the international Conference of Parties,[lv] can increase the visibility of the RDF policy agenda, facilitate coordination, and engage stakeholders. The

[lv] UNFCCC COP https://unfccc.int/process/bodies/supreme-bodies/conference-of-the-parties-cop

proposed conference is an event in which policymakers and other local stakeholders could convene to achieve region-wide commitments on decarbonization. While the conference could take place annually, it might follow the international COP model in which every fifth year there is a larger conference that aligns with the release of a report. A conference is also a familiar idea that is accessible to policymakers as well as industry leaders.

From the RDF to an Institutional Structure for Decarbonization

Figure 7.5 shows the full process that builds on modeled pathways from the RDF with an institutional structure that enables an evolving governance and an annual COG to promote innovative and lasting solutions for decarbonization.

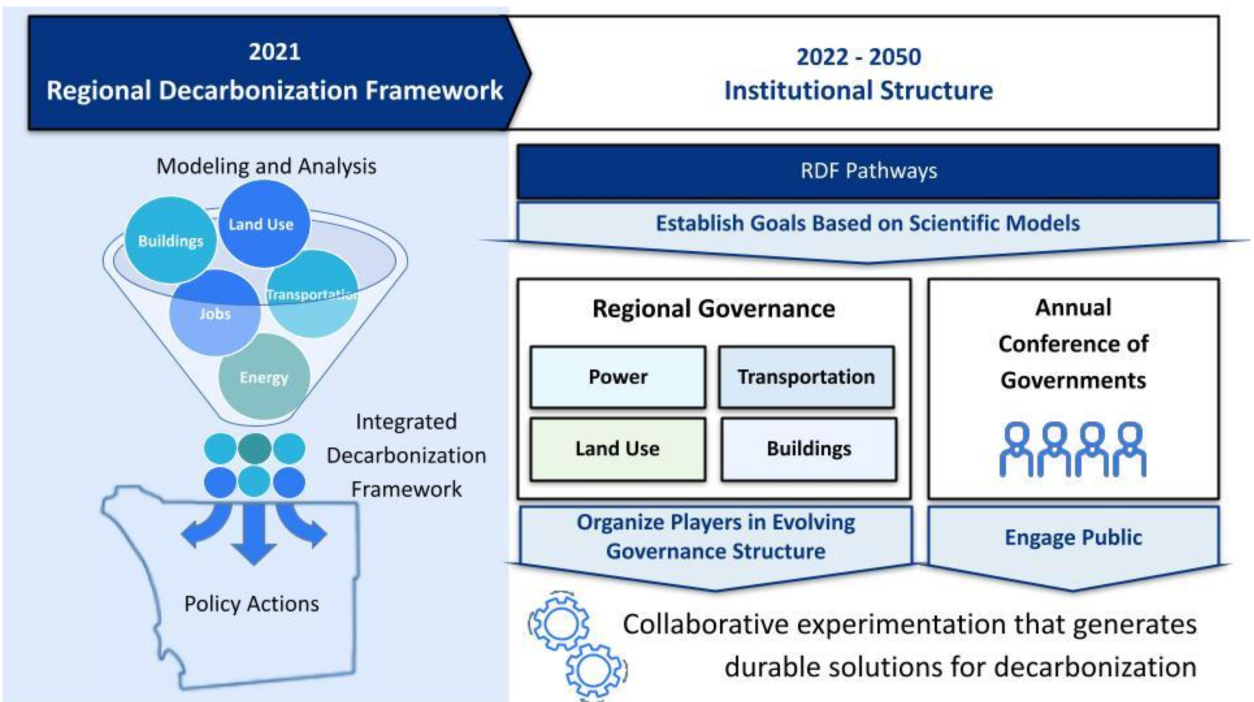


Figure 7.5. Full Process from RDF to an Institutional Structure.

Key State and Federal Policies Critical to Decarbonization at the Local Level

While local governments are on the front lines of decarbonization, they are limited in statutory and budgetary authority. For this reason, local governments are the largest lobbying presence in Sacramento.[24] The governments in the San Diego region should identify key state and federal policies necessary to achieve decarbonization at the local level. Here, we provide key pillars and policies, drawn from Williams et al.[25], and the US Zero Carbon Action Plan[3] that can guide policymakers efforts to influence state and federal level policy. For a more detailed discussion of state level policies for decarbonization, see the Local Policy Opportunity Analysis of the RDF.

1. **Electricity Decarbonization.** In the near term, falling costs of wind, solar and storage technologies make renewables an important strategy for decarbonizing the electric sector.
   State and Federal Policies
   - Clean energy standards: Price the carbon externality
   - Storage: Require sufficient storage to ensure reliability
   - Offshore wind: Accelerate leasing development of offshore wind areas
   - Oil and gas moratorium: Establish a moratorium on all further on and offshore oil and gas exploration
   - Research, development, demonstration, and deployment: Create incentives for the innovation and adoption of new technologies.
   - Expansion of the grid: Increased coordination on transmission upgrades and expansion among grid connected states and federal agencies

2. **Energy Efficiency and Conservation.** Action taken to increase energy efficiency and conservation will reduce the increasing demand for electricity generation. Additionally, efficiency can lower costs for governments and ratepayers.
   State and Federal Policies
   - Efficiency standards: Broaden and tighten standards across a wider range of end uses
   - Discourage single occupancy vehicles: Financial support for transit infrastructure and allow for greater regulation of vehicles
   - Remote work: Support remote work through broadband expansion and incentives
   - Aircraft: Incentivize low carbon aircraft fuel and invest in research of new technologies
   - Dietary guidelines: Expand dietary guidelines to include carbon footprint
   - Food waste: Incentivize the reduction of household and post-harvest food waste

3. **Electrification of Buildings and Transport.** Electrification is an essential strategy to achieve decarbonization by mid-century while keeping costs relatively low.
   State and Federal Policies
   - Clean Air Act: Tighten GHG emissions standards through the Clean Air Act
   - EV charging: Expand EV charging stations
   - Biofuels: Restrict biofuels to hard-to-decarbonize transport (e.g., heavy duty vehicles, aviation, shipping)
   - Mandates: Nationwide EV mandates similar to California's
   - Hydrogen: Create incentives and support infrastructure for green hydrogen development and distribution
   - Energy codes: Require states to adopt an energy code to achieve maximum possible electrification and efficiency
   - Enforcement: Funding for the enforcement of new building standards
   - Equity: Subsidize the transition of low-income households to electrify buildings and transport

4. **Carbon Capture**. Removal of CO_2 from combustion processes as well as from the air are necessary components of achieving decarbonization and eventually negative emissions.
   State and Federal Policies
   - RDD&D: Invest in Carbon Capture and Storage (CCS) to achieve necessary scale
   - Procurement: Direct funding through procurement by federal agencies
   - 45Q: Increase the size of the 45Q tax credit for CCS
   - Clean Energy Standard: Make CCS eligible for clean energy standard
   - Negative Agricultural Emissions: Incentivize farmers to store carbon in soils
   - Carbon Pricing: Create a price on emissions that incentivizes both CCS and reforestation efforts on private lands

Strategies to Upscale and Generate Followership

San Diego's contribution to global carbon emissions is .08%, a proportion that will only decrease as efforts to decarbonize continue and emissions in other regions rise. The pre-pandemic carbon dioxide equivalent emissions from the San Diego region were approximately 35 million metric tons ($MMTCO_2e$).[11] Pre-pandemic emissions were roughly 425 $MMTCO_2e$ in California,[26] 6,558 $MMTCO_2e$ in the US,[27] and 43,100 $MMTCO_2e$ globally.[28] Therefore, for San Diego to have a meaningful impact on atmospheric carbon, it must demonstrate successful innovations that generate local benefits and engage other regions to follow its lead. If from the start, San Diego focuses on the diffusion of technologies and policies to other regions, the region can be a leader that generates followership among the many other regions struggling with similar challenges in the effort to decarbonize.

Mechanisms for Upscaling

Upscaling[lvi] can be vertical (higher levels of governance) or horizontal (across peer regions).[5] There are several mechanisms identified in the peer-reviewed literature that can provide guidance for the San Diego region to achieve influence beyond its borders summarized in Figure 7.6.

- **Political Entrepreneurship:** Local leaders seeking to achieve influence beyond the borders of their jurisdiction can lead to upscaling.[7,9,23,29] In the San Diego context, providing a platform for local political entrepreneurs through the COG may incentivize action on climate.

[lvi] The World Bank defines upscaling as "expanding, adapting and sustaining successful policies, programs or projects in different places and overtime to reach a greater number of people" (World Bank, 2005).

- **Policy Entrenchment:** According to Bernstein and Hoffman[30] entrenchment of climate policy can lead to catalytic impact beyond the local level. They identify norm changing, capacity building, and coalitions as the key mechanisms to achieve entrenchment. In a case study of Palo Alto, California, Anderton and Setzer[7] identify local governance actions to achieve entrenchment: 1) legislative mandates that are enforceable in courts, 2) platforms to promote reforms, and 3) long-term visions. These key mechanisms ensure the stickiness of local policies and allow for broader impact and can be embedded into regional governance structures.

- **Incentivize Competition**: Competition among local jurisdictions can provide incentives for innovation that lead to the emergence of scalable policies and technologies that are useful in other regions.[9] In San Diego, existing competition between jurisdictions can be amplified through pilot funding.

In addition to mechanisms identified here, Chapter 9: *San Diego as a Model Chapter* provides further insight on how the processes created through the creation of the RDF can be used as a model in other regions.

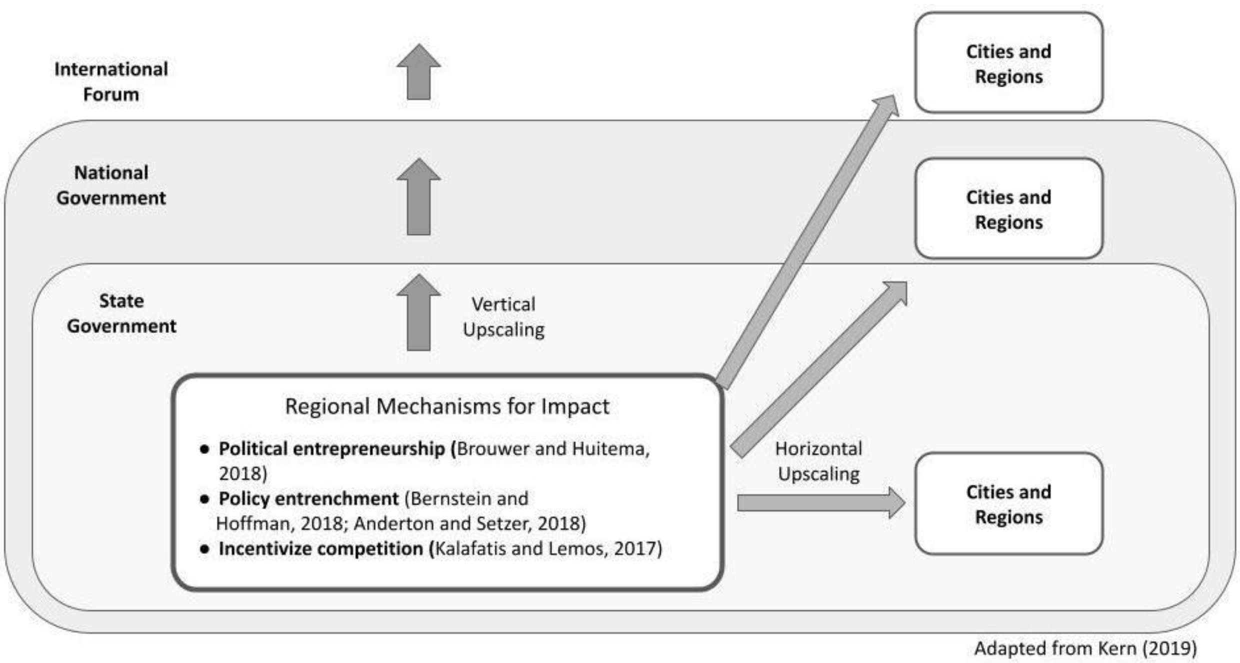


Figure 7.6. Mechanisms for Vertical and Horizontal Upscaling of Local Policy

7.6 Conclusion

One of the lessons from the pandemic is that systems need to be flexible to changing science and allow for ongoing learning from front-line experts on implementation. The same should be true for the historic task of transitioning the regional economy from fossil fuels to decarbonized sources of energy. The structures, mechanisms, and principles proposed in this chapter are meant to provide initial guidance on the design and implementation of a process to achieve climate ambitions. However, the process can, and should, evolve over time as science and technology advance. The collaboration established in the creation of the RDF itself provides a good starting point for the region. The parts of this collaboration that work well, should be developed, and scaled up.

Works Cited:

1. Castán Broto, V., & Bulkeley, H. (2013). A survey of urban climate change experiments in 100 cities. *Global Environmental Change*, *23*(1), 92–102. https://doi.org/10.1016/j.gloenvcha.2012.07.005

2. Measham, T. G., Preston, B. L., Smith, T. F., Brooke, C., Gorddard, R., Withycombe, G., & Morrison, C. (2011). Adapting to climate change through local municipal planning: Barriers and challenges. *Mitigation and Adaptation Strategies for Global Change*, *16*(8), 889–909. https://doi.org/10.1007/s11027-011-9301-2

3. SDSN. (2020). *Zero Carbon Action Plan*. Sustainable Development Solutions Network. https://irp-cdn.multiscreensite.com/6f2c9f57/files/uploaded/zero-carbon-action-plan.pdf

4. Victor, D. G., & Muro, M. (2020, October 22). Cities are pledging to confront climate change, but are their actions working? *Brookings*. https://www.brookings.edu/blog/the-avenue/2020/10/22/cities-are-pledging-to-confront-climate-change-but-are-their-actions-working/

5. Kern, K. (2019). Cities as leaders in EU multilevel climate governance: Embedded upscaling of local experiments in Europe. *Environmental Politics*, *28*(1), 125–145. https://doi.org/10.1080/09644016.2019.1521979

6. Morrill, R. L. (1989). Regional Governance in the United States: For Whom? *Environment and Planning C: Government and Policy*, *7*(1), 13–26. https://doi.org/10.1068/c070013

7. Anderton, K., & Setzer, J. (2018). Subnational climate entrepreneurship: Innovative climate action in California and São Paulo. *Regional Environmental Change*, *18*(5), 1273–1284. https://doi.org/10.1007/s10113-017-1160-2

8. Garrick, D. San Diego and area cities getting $600M in federal COVID-19 relief to help replace lost tax revenue. The San Diego Union-Tribune (2021).

9. Kalafatis, S. E., & Lemos, M. C. (2017). The emergence of climate change policy entrepreneurs in urban regions. *Regional Environmental Change*, *17*(6), 1791–1799. https://doi.org/10.1007/s10113-017-1154-0

10. Nikolewski, R. Encinitas just banned natural gas in new buildings, including homes - The San Diego Union-Tribune. The San Diego Union-Tribune (2021).

11. SANDAG. (2018). *Climate Change White Paper*. San Diego Association of Government.

12. Holcombe, R. G., & Williams, D. W. (2009). Are There Economies of Scale in Municipal Government Expenditures? *Public Finance and Management*, *9*(3), 416–438.

13. Jordan, A., & Huitema, D. (2014). Innovations in climate policy: The politics of invention, diffusion, and evaluation. *Environmental Politics*, *23*(5), 715–734. https://doi.org/10.1080/09644016.2014.923614

14. Trumbull, K., & DeShazo, J. R. (2021). *Southern California Regional Energy Needs Assessment* (p. 85). Luskin Center for Innovation.

15. Sabel, C., & Victor, D. G. (2020, November). How to Fix the Climate [Text]. *Boston Review*. https://bostonreview.net/forum/charles-sabel-david-g-victor-how-fix-climate

16. Nikolewski, R. County to join 5-city CCA as alternative to SDG&E. Will it bring lower electric rates? The San Diego Union-Tribune (2021).

17. Forrest, K. E., Tarroja, B., Zhang, L., Shaffer, B., & Samuelsen, S. (2016). Charging a renewable future: The impact of electric vehicle charging intelligence on energy storage requirements to meet renewable portfolio standards. *Journal of Power Sources*, *336*, 63–74. https://doi.org/10.1016/j.jpowsour.2016.10.048

18. Margoni, L. (2017, June 14). Nuvve and UC San Diego to Demonstrate Vehicle-to-Grid Technology Through Energy Commission Grant. *UC San Diego News*. https://ucsdnews.ucsd.edu/pressrelease/nuvve_and_uc_san_diego_to_demonstrate_vehicle_to_grid_technology

19. Massachuessets. (2020). *Massachusetts Decarbonization Roadmap* (p. 92). MA Executive Office of Energy and Environmental Affairs.

20. Smith, L. A., & Stern, N. (2011). Uncertainty in science and its role in climate policy. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *369*(1956), 4818–4841. https://doi.org/10.1098/rsta.2011.0149

21. Reed, A., Ericson, S., Bazilian, M., Logan, J., Doran, K., & Nelder, C. (2019). Interrogating uncertainty in energy forecasts: The case of the shale gas boom. *Energy Transitions*, *3*(1), 1–11. https://doi.org/10.1007/s41825-019-00015-9

22. He, G., Lin, J., Sifuentes, F., Liu, X., Abhyankar, N., & Phadke, A. (2020). Rapid cost decrease of renewables and storage accelerates the decarbonization of China's power system. *Nature Communications*, *11*(1), 2486. https://doi.org/10.1038/s41467-020-16184-x

23. Brouwer, S., & Huitema, D. (2018). Policy entrepreneurs and strategies for change. *Regional Environmental Change*, *18*(5), 1259–1272. https://doi.org/10.1007/s10113-017-1139-z

24. Myers, J. (2017, August 6). Column: Political Road Map: No one spends more on lobbying in Sacramento than local governments. *Los Angeles Times*. https://www.latimes.com/politics/la-pol-ca-road-map-lobbying-local-governments-20170806-story.html

25. Williams, J. H., Jones, R. A., Haley, B., Kwok, G., Hargreaves, J., Farbes, J., & Torn, M. S. (2021). Carbon-Neutral Pathways for the United States. *AGU Advances*, *2*(1), e2020AV000284. https://doi.org/10.1029/2020AV000284

26. CARB. (2020). *Air Quality and Emissions Data and Statistics*. California Air Resources Board. https://ww3.arb.ca.gov/html/ds.htm

27. EPA. (2019). *Inventory of U.S. Greenhouse Gas Emissions and Sinks* [Reports and Assessments]. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks

28. GCP. (2021). *Global Carbon Project (GCP)*. Global Carbon Project (GCP). https://www.globalcarbonproject.org/

29. Huitema, D., Boasson, E. L., & Beunen, R. (2018). Entrepreneurship in climate governance at the local and regional levels: Concepts, methods, patterns, and effects. *Regional Environmental Change*, *18*(5), 1247–1257. https://doi.org/10.1007/s10113-018-1351-5

30. Bernstein, S., & Hoffmann, M. (2018). The politics of decarbonization and the catalytic impact of subnational climate experiments. *Policy Sciences*, *51*(2), 189–211. https://doi.org/10.1007/s11077-018-9314-8

8. Local Policy Opportunity

Scott Anders, Energy Policy Initiatives Center, University of San Diego
Nilmini Silva Send, Energy Policy Initiatives Center, University of San Diego
Joseph Kaatz, Energy Policy Initiatives Center, University of San Diego
Yichao Gu, Energy Policy Initiatives Center, University of San Diego
Marc Steele, Energy Policy Initiatives Center, University of San Diego

8.1 Executive Summary

This chapter will be developed based in part on the initial drafts of the other chapters of this report. This draft provides an overview of the approach the Energy Policy Initiatives Center (EPIC) will use to identify local policy opportunities.

The overall goal of the Local Policy Opportunity chapter is to identify local policy opportunities that support the pathways to deep decarbonization identified in the Regional Decarbonization Framework technical analysis.

To achieve this overall goal, EPIC will conduct analysis to:

- Identify the authority of local governments and agencies to act to influence and regulate GHG emissions, including summary of key players and key legislation and regulation at the federal and state levels to help to clarify the ability of local governments to act to reduce greenhouse gas emissions;
- Evaluate adopted and pending climate action plans (CAPs) to determine the level of policy commitments and to determine if there are any policies that could be adopted by other local jurisdictions; and,
- Conduct a literature review to determine if there are policies not included in regional CAPs but that could support GHG reductions.

Results of this analysis will:

- Identify policy opportunities to support the decarbonization pathways; and,
- Identify opportunities where regional collaboration can enhance and improve GHG reductions.

Figure 8.1 summarizes the overall project approach.

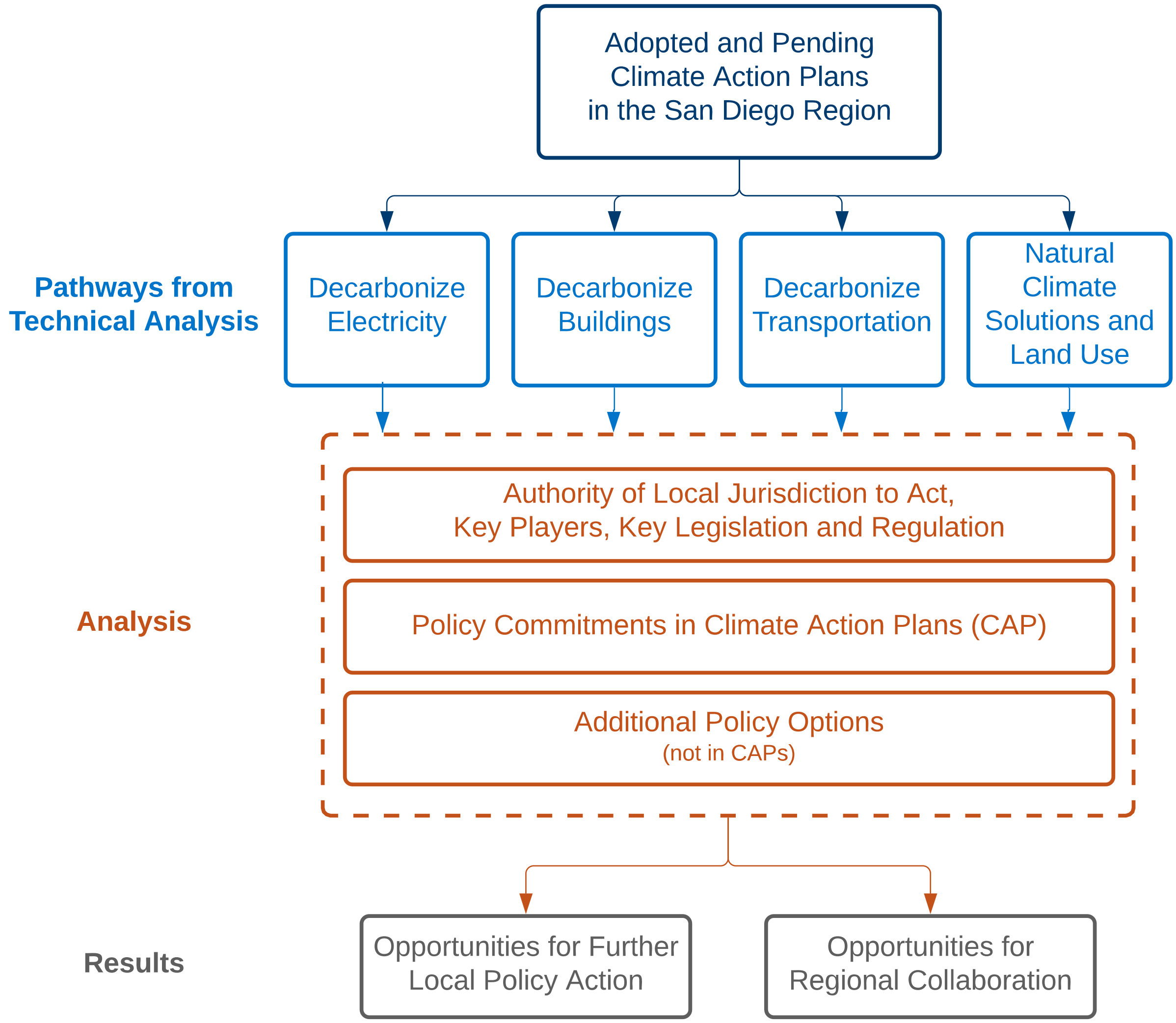


Figure 8.1. Overall Approach to Identifying Local Policy Options.

The following sections will summarize each aspect of this overall approach.

8.2 Adopted and Pending Climate Action Plans

EPIC will update its Mitigation Measure Database to include the most recently adopted and pending climate action plans (CAP) in the San Diego region. We will modify the database to facilitate analysis necessary for this project, including alignment with findings in the technical chapters of this report. The database contains information on all measures in CAPs adopted since 2010 and draft CAPs that are complete but not yet adopted (pending).

Figure 8.2 summarizes which CAPs we plan to include or exclude from the analysis. We propose to include pending CAPs to represent recent policies and actions. Also, we propose to exclude

City of National City because its CAP was adopted in 2011 and is an outlier among the sample of CAPs. Further, its methods, data, and measures predate significant development in methods and state guidance. Two CAPs – County of San Diego and El Cajon – were withdrawn or invalidated. Because these are no longer valid and cannot be considered a policy commitment, we will exclude them from the analysis.

Jurisdiction	Year Adopted	Included?
Carlsbad	2020	Y
Chula Vista	2017	Y
Coronado	Pending	Y
County, SD	Withdrawn	N
Del Mar	2016	Y
El Cajon	Withdrawn	N
Encinitas	2020	Y
Escondido	2021	Y
Imperial Beach	2019	Y
La Mesa	2018	Y
Lemon Grove	2020	Y
National City	2011	N
Oceanside	2019	Y
Poway	NA	N/A
San Diego	2015	Y
San Marcos	2020	Y
Santee	2020	Y
Solana Beach	2017	Y
Vista	Pending	Y

Figure 8.2. CAPs Included in Local Policy Analysis.

Focusing on more recently adopted and pending CAPs improves the analysis in the following ways:

- Provides a more up-to-date sample of measures;
- Creates a more consistent sample of measures that are more closely aligned with current federal, state, and regional efforts including the San Diego Association of Government's (SANDAG) Regional Climate Action Planning (ReCAP) Framework; and
- Provides a collection of measures that rely on more consistent methodologies for GHG reduction calculations as methods may evolve over time.

8.3 Decarbonization Pathways

The local policy analysis is based in part on the findings and frameworks of the technical chapters of this document, including:

- Chapter 2: Geospatial Analysis of Renewable Energy Production
- Chapter 3: Transportation Sector Regional Plans and Decarbonization
- Chapter 4: Natural Climate Solutions and other Land Use Considerations
- Chapter 5: Decarbonization of Buildings

Figure 8.3 illustrates the organizational structure for the analysis and eventual chapter. Our analysis will cover all four areas of decarbonization in these chapters; Figure 8.3 focuses on the main decarbonization pathways. These three pillars of decarbonization – focused on buildings, electricity supply, and transportation – represent both the highest emitting sectors and those with the highest potential to reduce GHG emissions. Natural climate solutions and other land uses, including agriculture, are important and will be included in the analysis but to a lesser extent that the three main pathways. The broad pathways can be further organized into subcategories.

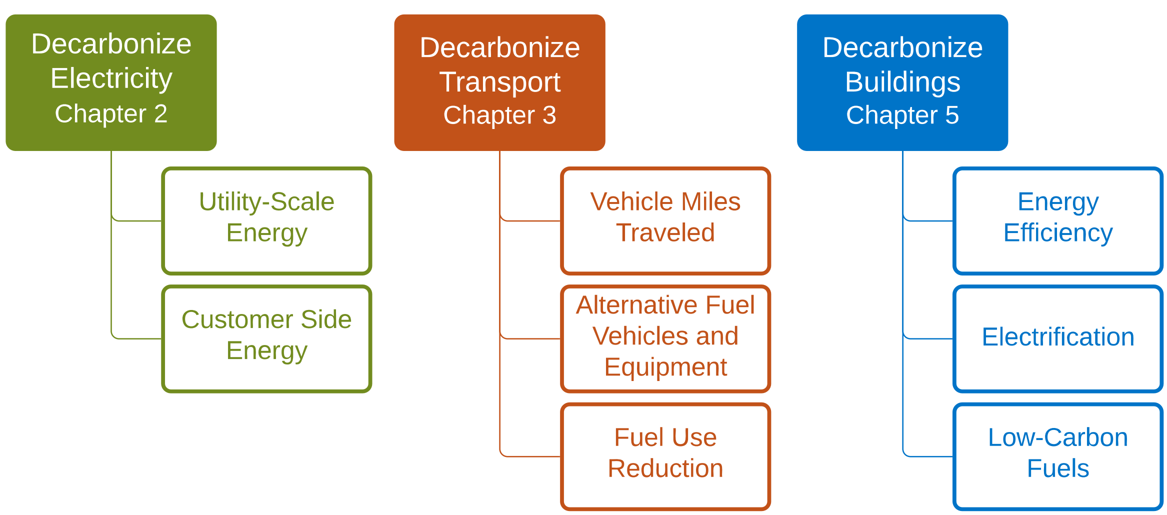


Figure 8.3. Main Decarbonization Pathways and Subcategories.

Each of the subcategories contains more specific local policy categories. For example, policies to reduce vehicles miles traveled could include the following.

- Bike
- Walk
- Mass Transit
- Parking Reductions
- Commuter TDM
- Smart Growth Development
- Micromobility (excluding bicycles)
- Complete Streets

These local policy categories can be used to conduct a more detailed analysis of policies in CAPs.

Analysis

Our analysis to identify local policy opportunities will include three elements:

- Assess the local governments ability to act to influence or regulate GHG emissions. As part of this we will identify the authority of local governments and relevant agencies; identify the key players at the federal, state, and local levels; and identify key legislation relevant to each decarbonization pathway and subcategory (Figure 8.3).
- Evaluate adopted and pending climate action plans (CAPs) to determine the level of policy commitments and to determine if there are any policies that could be adopted by other local jurisdictions; and,
- Conduct a literature review to determine if there are policies not included in regional CAPs but that could support decarbonization pathways.

The following sections provide additional information on each element.

Authority, Key Players, Key Legislation

EPIC will provide an overview of the following aspects of the ability of local governments and agencies to influence or regulate GHG emissions.

- What constitutional or delegated authority exists for local action and to what extent is local authority preempted by federal or California law or regulation?
- What state and federal players can influence or regulate GHG emissions (e.g., state regulators like the California Air Resources Board) and what are their respective roles relative to local jurisdictions and agencies?
- What key legislation or regulation applies in a given area (e.g., building electrification) that will affect GHG emissions at the local level?

Local Authority

These sections will discuss existing local jurisdiction authority to regulate GHG emissions by analyzing the broad constitutionally derived “police authority” of local governments as well as delegated authority from California or federal law. How and to what extent preemption exists under California and federal law will be discussed to determine where local authority is clear and where local authority is either uncertain or preempted. Police authority will also be discussed in terms of whether a local government is a charter or common law city or county. The analysis will address authority over direct emissions, procurement of electric and natural gas supply, regulation of demand for electricity and natural gas, land use, and transportation.

Key Players

The federal and California entities that are responsible for regulating GHG emission by source will be highlighted and used to discuss the role and authority of local governments. These will include the U.S. Environmental Protection Agency, Department of the Interior (including Bureau of Land Management, National Parks Service, and U.S. Fish and Wildlife), Department of Agriculture (including the National Forest Service), Department of Defense, San Diego County Water Authority, California Air Resources Board, California Energy Commission, and California Public Utilities Commission. Local government entities will be identified and discussed as well. These will include all cities and the county, San Diego Association of Governments, San Diego Pollution Control District, Port of San Diego, school districts, water districts, universities, community college districts, San Diego Metropolitan Transit System, North County Transit District, and any other relevant local government entity.

Key Legislation and Regulation

Key legislation and regulations will be identified and analyzed to determine local authority to act. This will include identifying relevant constitutional language, statutes, and regulations applicable to local jurisdictions. For example, although emissions from passenger cars and light-duty trucks is the largest single source of emissions in the region, local governments are preempted from setting tailpipe emissions standards under the federal Clean Air Act, but California acts with delegated authority under the Clean Air Act to adopt and enforces aggressive mobile source regulations in this area. Local jurisdictions act with limited authority over mobile source emissions but still can act to influence fuel use by on-road vehicles through local land use, zoning, incentives, and permitting. In this way, we will show how local authority to act on GHG emissions is nested with state, and in some cases, federal authority. This can help identify areas where local authority may not exist but where advocacy of changes at the state and federal levels will be beneficial to local and regional GHG emissions levels.

Local Policy Commitments

EPIC will analyze CAP measures and supporting actions to identify current local policy commitments in the San Diego region that support decarbonization. To identify further opportunities, EPIC will:

- Update the CAP Mitigation Measure Database;
- Determine the distribution and frequency of measures across all CAPs;
- Determine the relative contribution of categories of CAP measures to the local GHG reduction commitment in CAPs;
- Determine how CAPs integrate social equity considerations.

Categorization

All CAP measures and supporting actions will be categorized by the following to EPIC-defined groups to facilitate multiple levels of analysis (Figure 8.3 above):

- Decarbonization pathway;
- Decarbonization pathway subcategory;
- Local policy category; and
- Implementation mechanism.

Categories will be defined in a way to align with the structure of the broader Regional Decarbonization Framework report and findings within other chapters. The implementation mechanism will identify how a jurisdiction intends to achieve some type of activity (e.g., through a requirement, incentive program, or education and outreach).

Additionally, specific policy categories will be further categorized where relevant. For instance, building electrification policy options differ between new construction and/or the current building stock, and between building types (e.g., residential and non-residential). This will permit further analysis to assist in identifying specific policy opportunities for the region and its jurisdictions.

Policy Distribution and Frequency

Outputs from the above analysis will include a summary of the number of jurisdictions that have committed to one or more policy actions organized by the categories listed above. We will develop summary tables to present findings from this analysis and inform what additional policy options exist for jurisdictions in the region. Table 8.1 is an illustrative example of how high-level results for building energy efficiency could be summarized.

Implementation Mechanism	Existing Building Stock		New Construction		Municipal Only
	Residential	Nonresidential	Residential	Nonresidential	
Policy Option: Information Disclosure					
Education, Outreach, & Coordination	32%	32%	-	-	-
Incentive Program	5%	5%	-	-	-
Requirement	16%	11%	-	-	5%
Policy Option: Implement Energy Efficiency Measure(s)					
Education, Outreach, & Coordination	47%	42%	21%	21%	5%
Incentive Program	26%	26%	-	-	-
Requirement	32%	37%	16%	21%	47%

Table 8.1. Percent of Jurisdictions with One or More Building Energy Efficiency.

CAP Measures or Supporting Actions

Summary tables similar to Table 8.1 will allow us to identify which policy options are frequently used by local jurisdictions to achieve GHG reductions and which policy options are not as common. In addition, these tables will illustrate where jurisdictions can look to achieve further reductions and identify potential opportunities to use an implementation mechanism that may achieve greater GHG reductions. For example, policies that rely on education and outreach are likely to achieve fewer, if any, reductions than an incentive program, which are likely to achieve fewer than a requirement. This can be paired with information collected on local authority to determine the extent at which jurisdictions can utilize certain implementation mechanisms (e.g., requirements).

Summary tables also illustrate the policies that have been adopted, but still have room to expand their scope. For instance, jurisdictions have committed to electrification requirements for new residential and/or nonresidential construction, but have few, if any, policies to electrify the existing building stock. This indicates an opportunity area, one that may see an outsized reduction in GHG emissions relative to what is currently in place, as the existing building stock is much larger than the anticipated amount of new development.

Contribution to Local GHG Reductions in CAP

To understand how these local policy commitments translate to GHG reduction contributions, a second analysis will be conducted to determine the relative contribution of CAP measures – grouped by decarbonization pathway and pathway subcategories – to the local GHG reductions expected from all local CAP measures.

There are challenges with comparing GHG emissions across CAPs. Currently, not all CAPs report GHG reductions in the same target year(s); however, EPIC has identified 2035 as a common reporting year for most CAPs and will analyze GHG reduction contributions estimated for that year. If a CAP does not have emissions reductions reported in 2035, then EPIC will assign 2035 reductions using one of two methods. First, if 2035 is in between two CAP target years, reductions will be linearly interpolated between those two years. Second, 2030 reductions will be carried over to 2035. These results will be shown alongside the regional GHG inventory to understand how reductions from local policy efforts align with emission sources (e.g., transportation or building energy) (Figure 8.4). EPIC is working to develop an intuitive method to express results of the GHG reduction contribution analysis for local policy commitments in CAPs.

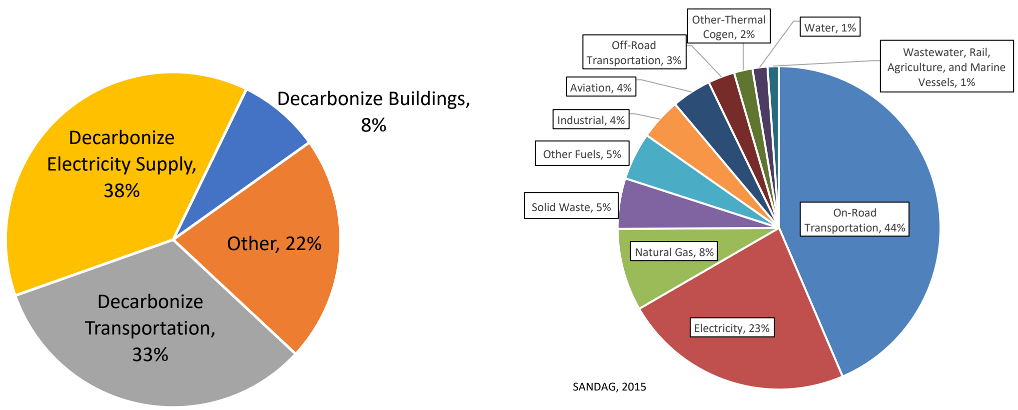


Figure 8.4. Average CAP Contribution to Local GHG Reduction by Decarbonization Pathway (left) and San Diego Regional GHG Inventory (right).

Results from the GHG contribution analysis will highlight where local policy commitments align, or do not align, with GHG inventories. For example, many CAPs rely on electric supply measures for a majority of their emissions reductions; however, the regional inventory shows that a significant majority (44%) of emissions come from the transportation sector. This signals a potential need – and opportunity – for more local policy that decarbonizes the transportation sector.

Equity

As part of the policy analysis, we will consider social equity in two ways. First, we will assess whether and how regional CAPs integrate social equity considerations. This includes whether there is a separate section on equity, whether equity is integrated into implementation sections, and whether CAPs address workforce development. Second, we will consider the equity implications of the local policy and regional collaboration opportunities. As an example, what equity implications result from widespread electrification of buildings and transportation and could regional programs be developed to address any impacts?

Limitations

There are several limitations associated with analyzing local policy commitments in CAPs, including:

- CAP language may be high-level and/or vague, requiring subjective judgment when categorizing the policy into one or more groups;
- CAPs may rely on different methods and inputs (e.g., emission factors) that may change over time or may vary based on the consultant preparing the CAP;
- Jurisdictions may not have activity in all emissions sectors (e.g., agriculture) and will consequently not have associated policies included in their CAP;
- Some jurisdictions may implement decarbonization-related policies that are not included within their CAP;
- Some CAP measures have, since adoption, been superseded by federal, state, and regional requirements and/or activity (e.g., low carbon fuel standards, updated building code standards, and SB 375); and
- CAP target years do not consistently align and, for some CAPs, data on GHG reductions in interim years may be limited.

To address these limitations, GHG reductions should not be summed across CAPs and results of the local policy commitments contribution analysis are meant to illustrate the relative magnitude of certain policy options only.

Additional Local Policy Options

In addition to the local CAP policy commitment analysis, EPIC will conduct a literature review to identify additional policy options not included in regional CAPs. For this, we will identify and review a range of sources, including CAPs from outside the region, journal articles, and related reports and papers. Research for this will also include key organizations that focus on the specific policy areas related to the decarbonization pathways, including for energy efficiency, for example, American Council for an Energy Efficient Economy (ACEEE), Alliance to Save Energy (ASE), RMI, Institute for Market Transformation, etc.

Timeline

Figure 8.5 provides a draft project timeline.

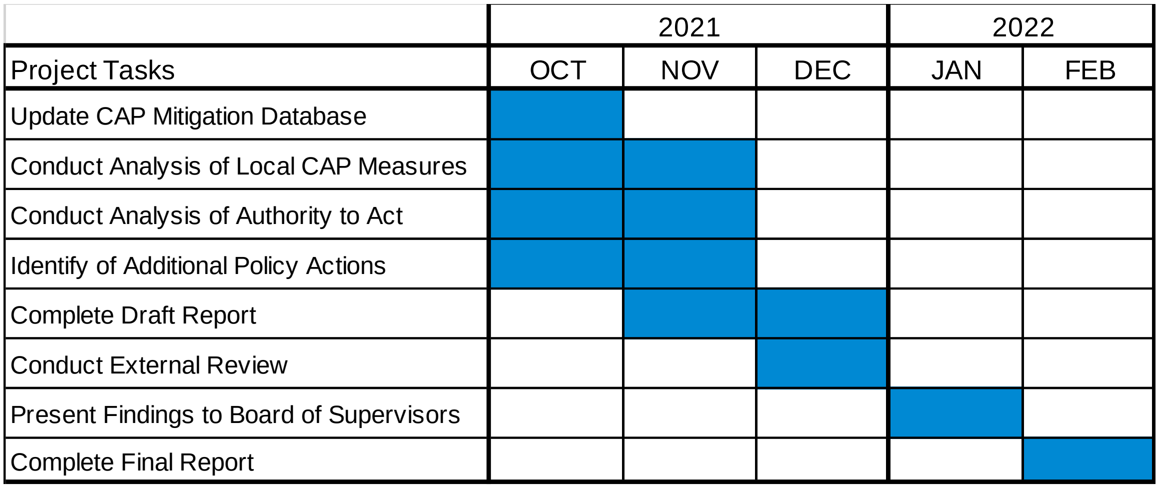


Figure 8.1. Draft Project Timeline.

9. San Diego as a Model

A Guide for aligning pathways, policies, and resources to realize win-win scenarios in the transition to net-zero

Elena Crete, UN Sustainable Development Solutions Network (SDSN)

9.1 Purpose

The County of San Diego Regional Decarbonization Framework is a novel demonstration of collaborative long-term planning which other regions and jurisdictions should adapt and replicate in order to keep global warming below 1.5 degrees C. With the Intergovernmental Panel on Climate Change (IPCC) now sounding the alarm on climate change with their 2021 Global Warming of 1.5 ºC Special Report, communities around the world are beginning to reflect on what reducing and eliminating emissions means for their specific contexts. While scientists agree we now have the technologies we need to enable the transition to net-zero, the exact configuration of those technologies, accompanied by supporting policy frameworks and financing, will need to be calibrated for specific conditions around the globe. Each local process must take into consideration their greenhouse gas emissions inventory, local economy and workforce, and long-term emissions reduction goals in a collaborative and transparent planning process. The process undertaken by the County of San Diego can serve as a case study for other jurisdictions across the U.S. and globally to learn from and replicate. In order to facilitate this dissemination, the project team is working closely with the UN Sustainable Development Solutions Network (SDSN) to showcase this effort alongside various international fora. Additionally, the project team will develop an accompanying Guide to serve as a toolkit for other municipalities and communities to follow in their pursuit of net-zero emissions. This Guide will serve as an addendum to the larger Regional Decarbonization Framework report. The purpose of this Guide is to distill the high-level process undertaken by the County, highlight the enabling factors for success, and provide a step-by-step instruction manual for other communities who wish to undertake similar long-term planning processes in their efforts to combat climate change.

9.2 Motivation

With broadband access now extending to the most remote parts of the world and the COVID-19 crisis encouraging professionals around the world to adapt to a virtual workplace, the opportunity for engaging stakeholders and sharing experiences is greater than ever. Over the last several decades there have been new consortiums and networks established that work both vertically and horizontally across our societies to align development agendas and resources to accelerate growth in the framework of sustainable development. One such consortium is working globally to elevate the academic and science community to highlight the multidisciplinary approach required to understand and achieve sustainable development, the UN Sustainable Development Solutions Network (SDSN).

SDSN was set up in 2012 under the auspices of the UN Secretary-General. SDSN mobilizes global scientific and technological expertise to promote practical solutions for sustainable development, including the implementation of the Sustainable Development Goals (SDGs) and the Paris Climate Agreement. SDSN works closely with United Nations agencies, multilateral financing institutions, the private sector, and civil society. SDSN is guided by a Leadership Council, which brings together global sustainable development leaders from all regions and all sectors, including civil society, public, and private sectors. Much of SDSN's work is led by National or Regional SDSNs, which mobilize knowledge institutions around the SDGs. Their research & policy work mobilizes experts from around the world on the technical challenges of implementing the SDGs and the Paris Climate Agreement. The SDG Academy leads the education work of the SDSN. As a member of the SDSN, UC San Diego has brought on SDSN as a consulting partner in order to ensure that the process and results of this project is firmly integrated into various multilateral fora, both within and alongside formal UN processes.

The SDSN is working to share the RDF project within three horizontal levels across its network. First **nationally,** the SDSN USA currently hosts nearly 150 institutions in over 44 states, Puerto Rico, and Washington, DC. These academic institutions all have local networks of sustainability practitioners working in various aspects of the SDGs. SDSN USA builds pathways towards the achievement of the UN Sustainable Development Goals in the United States by mobilizing research, outreach, collective action, and global cooperation. To accomplish this, they: facilitate and lead coalitions to address U.S. sustainability challenges; build sophisticated, practical systems for assessing progress; facilitate public awareness, education, and engagement; and link these efforts with policymakers and community leaders throughout the U.S. to result in lasting change.

The SDSN USA network is also part of a larger network of national and regional networks which make up the **international** framework of SDSN. With more than 1,500 members working across 44 national and regional networks worldwide, the SDSN USA is part of a global multidisciplinary consortium of experts and has access to thought-leaders around the world. This allows the network to share the results of the RDF directly with like-minded sustainability experts across various geographies and spectrums around the world who can glean important lessons learned from the RDF process and Guide.

Lastly, the SDSN serves as an observer organization to the United Nations Economic and Social Council (ECOSO) and United Nations Framework Convention on Climate Change (UNFCCC) processes and are also a partner in the Cities and Climate Change Science Conference which was co-sponsored by the IPCC in 2018. In 2021, this effort continued under the auspices of the Innovate4Cities Conference in October 2021, co-hosted by UN-Habitat and the Global Covenant of Mayors for Climate & Energy (GCoM). The RDF project was presented during the forum and the inputs of this event will serve to inform the 2022 IPCC Sixth Assessment Report on impact, adaptation and vulnerability to global climate change. These **global** consortiums provide an opportunity to showcase the results of this project and San Diego as a model to the world. With access to these foras, the RDF project can help inform global roadmaps and pathways to net-zero.

Outline of Guidebook:
-Background, Motivation and Target Audience
-Process Overview (description and graphic)
-How to Identify key sectors and stakeholders
    - Start by outlining supply and demand of emissions intensive commodities and activities in given jurisdiction (set boundary conditions)
-Meet the Team (skills mapping)
        -Power Mapping – Stakeholder Identity and Agency
            - Private, Public, Academia
-Project Methodology Summary: Open Mod tools available and requisite data
-Key Decision Trees / project milestones
-Community and Labor Union Engagement – Important Criteria for Success
-Outcome Gap Analysis
-Planning alongside uncertainty
-Getting Started: Step by Step

+Toolkit library – annotated bibliography of resources available from esteemed NGOs to support decarbonization planning

-How should the toolkit/guidebook be hosted? PDF and Online webpage
Examples:

- U.S. Climate Resilience Toolkit: This toolkit has a helpful "Explore the toolkit" function that walks site visitors through the resources available of the website.

- The Sierra Club's Building Electrification Action Plan for Climate Leaders has an action-plan format which could be a useful reference template for designing the decarbonization toolkit.
- RMI's Regulatory Solutions for Building Decarbonization Toolkit features both a downloadable report and a website visualization component.
- New Zealand's climate toolkit for business starts out with a quiz that then provides tailored recommendations for climate action.
- Oregon State University's Climate Impacts Research Consortium took the approach of posting a wide array of resources for climate change adaptation and mitigation on a single website.

Questions to be answered in the Guidebook:

- What are the key enabling factors to achieving net-zero?

Technological capacity; political support; sound financial opportunities/economic growth assurances; collaborative and transparent process

- What are the replicable parts of this project for other jurisdictions?

Technical/Political/Community Engagement; Scalability of this approach

- Who is the primary audience for the Toolbox?

City, County, and regional governing bodies (US focus)

- What elements of the project require specialized skills?

Energy and spatial modeling; Policy GAP analysis; Community engagement

- What were the enabling conditions that enabled this project (what's missing)?

Political will, regulatory framework, local and state goals (medium and long-term)

- Which elements of this project are specific to San Diego and which can be applied to other regions?

Multijurisdictional goal alignment – federal, state, local; History of Climate Action Planning; Climate impact risk assessments Ex. SLR; GHG Inventory

- Identify and mitigate areas of contention from the start

Identify winners and losers; Quantify impacts of inaction; Supply Chain uncertainties; Risk profiles of stakeholders; Local industry and labor force; Tax revenue sources; Political cycles; Lobbies; etc.

- How to identify motivating elements of the transition to bridge industries and political parties?

Ex. Public transport

Appendix A. Summary of Statewide Energy System Modeling

As noted in the Study Framework chapter, the detailed sectoral analysis presented in the RDF was informed by energy system modeling at the state and national level. This work was done by Evolved Energy Research using the modeling tools EnergyPATHWAYS and RIO presented in Williams et al. (2021).[1] These same modeling tools were also used in the Princeton Net-Zero America study,[2] SDSN's Zero Carbon Action Plan,[3] and the Decarb America Initiative.[4] Unlike in these national studies, the state-level analysis includes two zones for California (north and south), zones for each of the other ten western states, and a final "other states" zone that helped to set the boundary conditions for the west around variables such as the availability of imported biofuels. The zonal representation is shown graphically in Figure A1 and is the same used for the analysis in Wu et al. (forthcoming).

The Study Approach also notes that the energy system modeling was not prescriptive when it came to the RDF. Instead, it is meant to guide more detailed local-level analyses capturing the specific circumstances of the San Diego region. The larger energy system context presented here creates an important backdrop for the region and explicitly acknowledges the interconnectedness of our energy and land systems. This appendix focuses on summary results from the EnergyPATHWAYS and RIO modeling, along with the basic input assumptions. Readers looking for a more detailed description of both the methods and the underlying system-level dynamics outside of California should reference Williams et al. (2021).

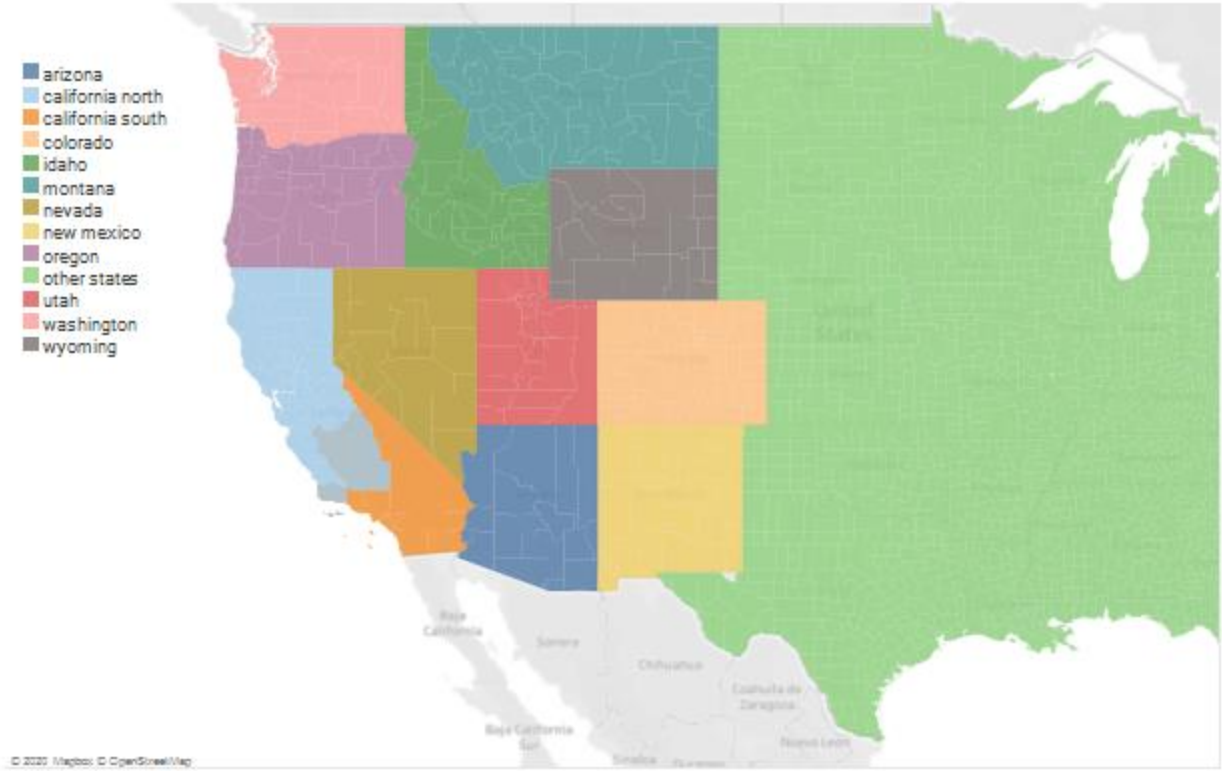


Figure A1. Western state representation used in the EnergyPATHWAYS and RIO models that helped provide the broader energy system context for the San Diego region.

Informational flow: state-wide energy system models to regional pathways

The modeling framework used to identify decarbonization pathways at the state and national levels is organized around energy demand and supply. First, modelers use EnergyPATHWAYS to estimate final energy demand by type in up to 64 different demand subsectors for each study year (2020-2045). Inputs to the model include the most recent data on subsector final energy demand from the Energy Information Agency Annual Energy Outlook and modelers' assumptions of how technology-use will change over time (e.g. the rate that customers switch from fossil-fuel to electric appliances or cars, or how the economy activities may shift over time). The resulting subsector estimates of energy demand are time-varying, meaning that they include hourly estimates of energy demand for a set of representative days. Next, modelers input the hourly and yearly demand estimates into the RIO model, which determines the "best" set of new and existing energy supplies to meet demand in each geographic area. The choices are constrained by things like emissions limits, operational constraints (e.g. the need to balance supply and demand in real time), resource scarcity (e.g. biomass), or policy (eg. a ban on nuclear energy). The result is a least-cost pathway--an energy investment "plan"--under the assumptions and constraints applied.

Past decarbonization models have found that reaching net-zero nationwide and in California by 2045 can be done at manageable cost. In their national-level model, Williams et al (2021) estimate that net costs of decarbonization would fall between 0.4% and 0.9% of GDP, depending on the scenario, compared to a historical range of total US spending on energy between 5.5%-13% of GDP from 1970 to the present. The geographic distribution of these costs are not modeled at a high resolution, and so we do not present total decarbonization costs for the San Diego region in the RDF. However, it should be noted that higher costs in a particular geographic region are not necessarily a negative, as they imply greater investment, growth in local industry and employment, and new infrastructure.

These system-level decarbonization pathways provide a useful guide for the detailed, sector-level pathways laid out in the remainder of the RDF. No individual pathway should be treated as a plan because the underlying assumptions are too uncertain. However, by applying several different sets of assumptions and constraints--scenarios--to generate several different least-cost pathways, modelers get a sense of which types of energy supply investments are most robust, or chosen as “best” in most circumstances. This gives policymakers a common general direction, at least initially, helping to alleviate policy gridlock, prevent conflicting approaches, and eliminate dead-end strategies.

Scenario Descriptions

A set of five scenarios were modeled to help inform the RDF. First, a reference, or “baseline,” scenario that does not enforce emissions constraints was run for comparison purposes. From there, the other four scenarios explore sensitivity to different uncertainties in behavior, societal preference, and technology development. These were chosen to reflect the broad debates happening around climate policy and human behavior at the state level, and reflect a wide range of plausible futures. The Central scenario meets reference energy service demand with high demand-side uptake of electric, efficient technologies and with all energy-supply technology options available. The Low Demand scenario uses assumptions from Williams et al. (2021) to examine the implication of higher energy conservation on mitigating emissions from the energy system. The Electrification Delay introduces a 20-year lag in the speed at which customers adopt electric technologies. Finally, the No Sequestration scenario disallows geologic storage of CO_2 and subsequently emphasizes drop-in use of clean fuels, rather than continued use of fossil fuels with captured carbon offsetting those emissions. This scenario reflects that, while technical potential exists for geologic storage of carbon in California, political, regulatory, and economic barriers may prevent this from becoming a reality. A summary of the inputs used across each of the five scenarios is provided in Table A1.

Table A1. Input summary for each of the five macro-energy scenarios analyzed in the EnergyPATHWAYS and RIO models.

		Reference	Central	No Sequestration	Electrification Delay	Low Demand
Energy Service Demand		Based on the 2021 U.S. Annual Energy Outlook with California specific updates for on-road transportation from the Air Resources Board.				Subsector specific reductions from Williams, Et Al (2021)
Efficiency	Buildings	AEO 2021 reference	Best available efficiency technologies become 100% of new sales by 2030			
	Industry	AEO 2021 reference	1% efficiency improvement per year above AEO 2021			
	Aviation	AEO 2021 reference	1.5% efficiency improvement per year above AEO 2021			
	Other Transport	Existing Standards				
Electrification	On-road transport	AEO 2021 reference	ZEV sales reach 100% by 2035	ZEV sales reach 100% by 2035	ZEV sales reach 100% by 2055	ZEV sales reach 100% by 2035
	Buildings	AEO 2021 reference	Electric technology sales 100% by 2035	Electric technology sales 100% by 2035	Electric technology sales 100% by 2055	Electric technology sales 100% by 2035
	Industry	None	Process heat electrification and direct hydrogen use. Carbon capture on cement from Princeton NZAP Study.			
Clean Electricity		Existing state policies throughout the western states				
Biomass Availability		Maximum of 524 TBtu/year from California sources				
Sequestration Availability		N/A	102 Mt/year	0 Mt/year	102 Mt/year	102 Mt/year
Emissions	California	None	Straight line CO2 emissions reduction from pre-COVID-19 emissions to a net-zero energy system in 2045. Gradual inclusion of all inter-state aviation within California's accounting.			
	Other states	None	Straight line CO2 emissions reduction from pre-COVID-19 emissions to a net-zero energy system in 2050.			

Model Implications and Supplementary Results

Some relevant results from the EER state-level energy system modeling are shown below in Figures A2-A10. Across the scenarios modeled, several broad themes emerge that inform the detailed sector-level pathways for the San Diego region.

In all scenarios consistent with net zero emissions state-wide by 2045, energy end-uses must rapidly electrify, implying dramatic reductions in the end-use of pipeline gas and gasoline fuel, relative to the reference scenario (Figure A2). This means that, even with uncertainty around the overall rate and extent of electrification, reaching net-zero emissions will require that nearly all light duty vehicles and many medium and heavy duty vehicles be electric by 2045 (Figure A7). Likewise, demand for heating and cooling in the built environment, mostly expected to increase (Figure A6) as new buildings are constructed and temperatures rise (Figure A5), must be met increasingly by electric devices.

The need for massive electrification drives the regional analyses of the transport and buildings sectors. In transport, the RDF pathways outlines a need for significant efforts across jurisdictions to rapidly increase EV adoption and the buildout of charging infrastructure. In buildings, the RDF pathway emphasizes efforts to incentivize adoption of efficient heat pump-based space and water heating systems in both new and existing buildings, with particular focus on assistance for low-income residents and rental buildings.

Simultaneously, the electric sector itself must decarbonize, which in California means massive increases in solar generation capacity and less in wind (Figure A3). This finding drives the regional energy production pathway analysis, which identifies substantial opportunity for solar development throughout the region.

Finally, the EER models show that, if allowed by policy, carbon sequestration will likely be necessary to achieve net-zero emissions. The land use and natural climate solutions regional pathway analysis broadly assumes that this will require some level of natural carbon sequestration and identifies land use and natural climate solutions which can enhance or increase net negative land emissions.

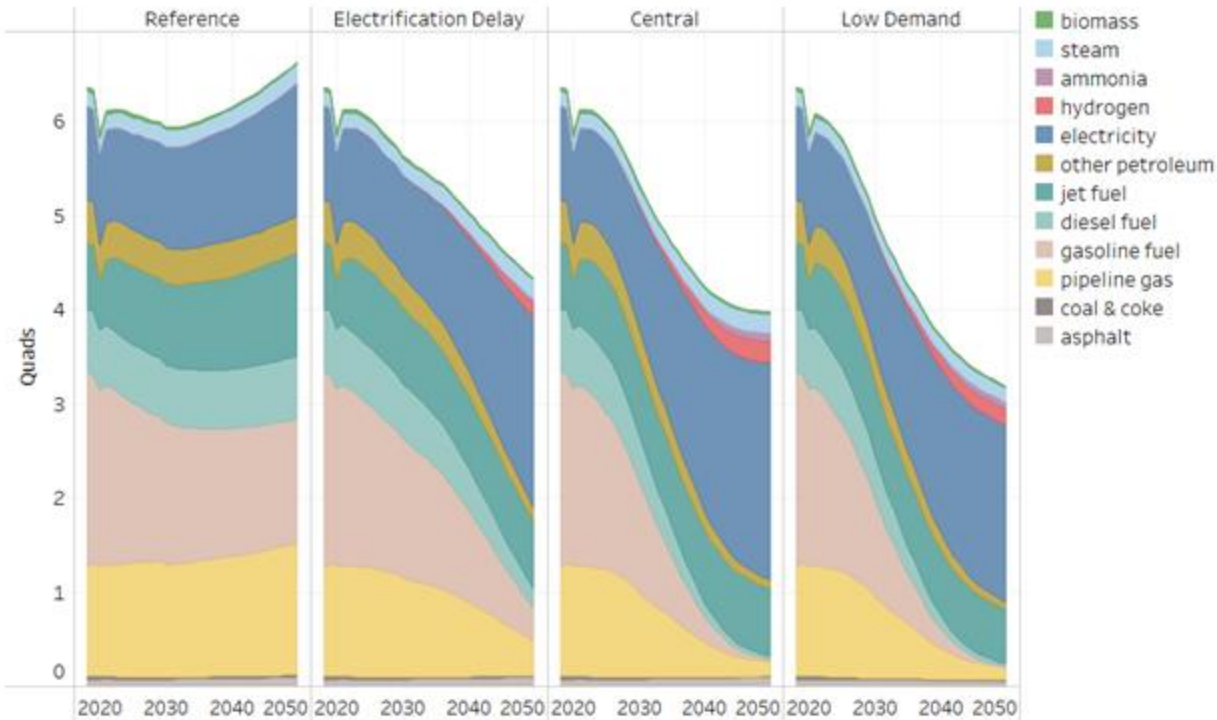


Figure A2. Final energy demand for different fuel blends in California. Final energy demand for the No Sequestration scenario is the same as that of the Central scenario; however, pipeline gas in the No Sequestration scenario would need to come from low carbon sources, such as drop-in fuels.

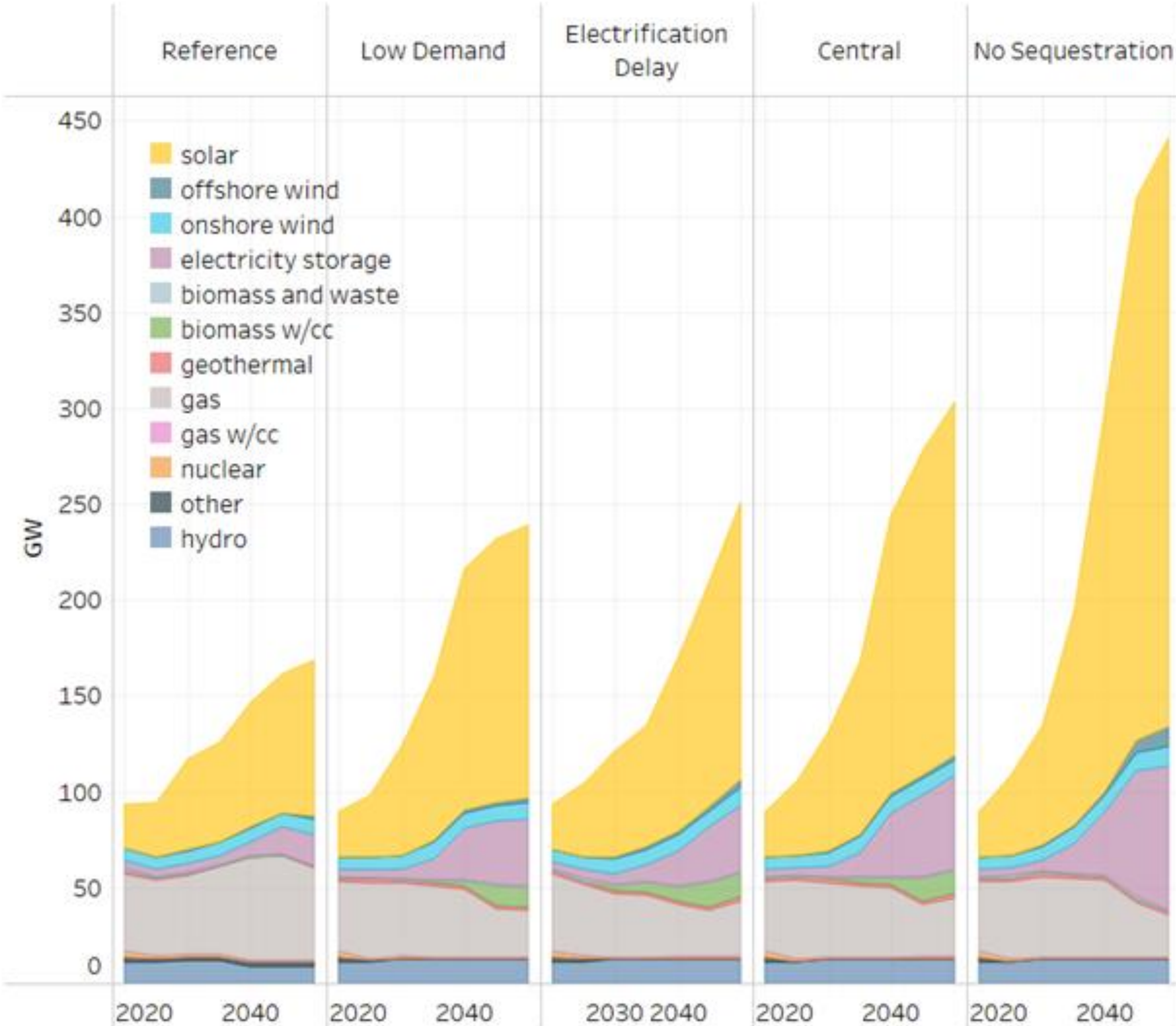


Figure A3. Total installed electricity capacity in California.

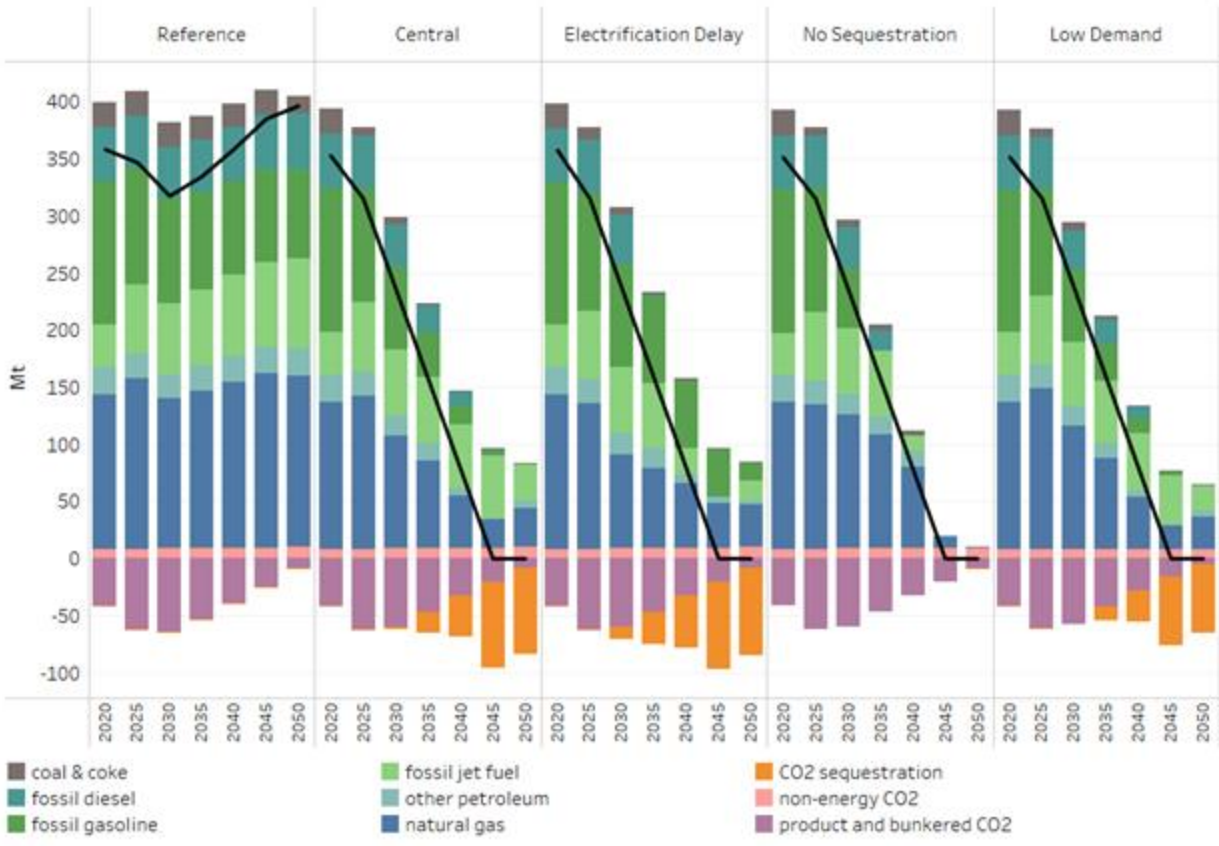


Figure A4. CO_2 emissions from energy and industrial processes in California. Colors above the x-axis represent positive emissions, and colors below represent offsetting negative emissions. The black line indicates net CO_2 emissions. Product and bunkered CO_2 is carbon that ends up sequestered in materials (e.g., asphalt) or CO_2 not counted in current inventories (e.g., interstate aviation).

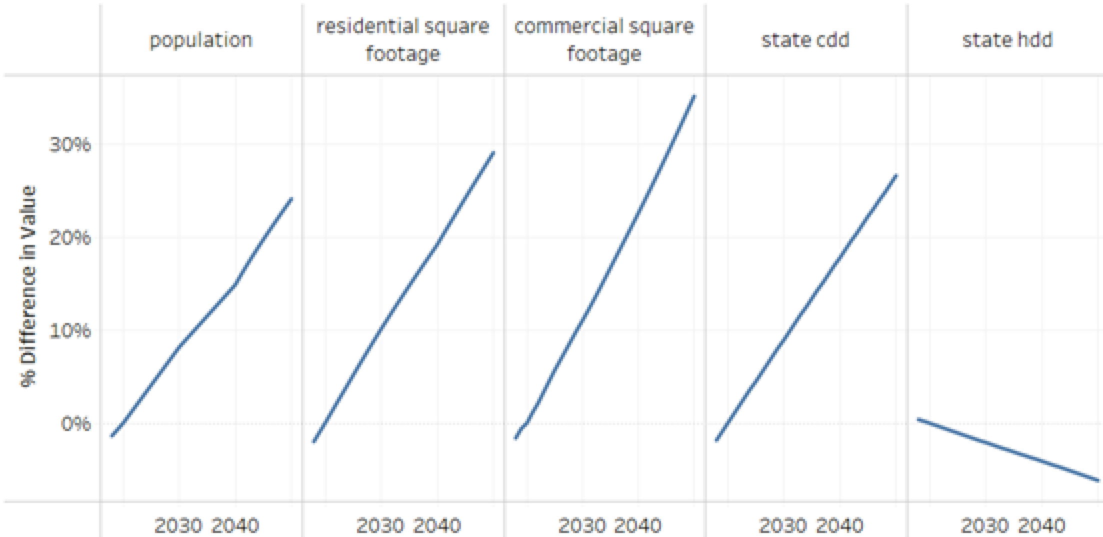


Figure A5. Percent change from 2020 to 2050 for some of the important drivers of energy service demand in California, where state CDD stands for cooling degree days and HDD stands for heating degree days.

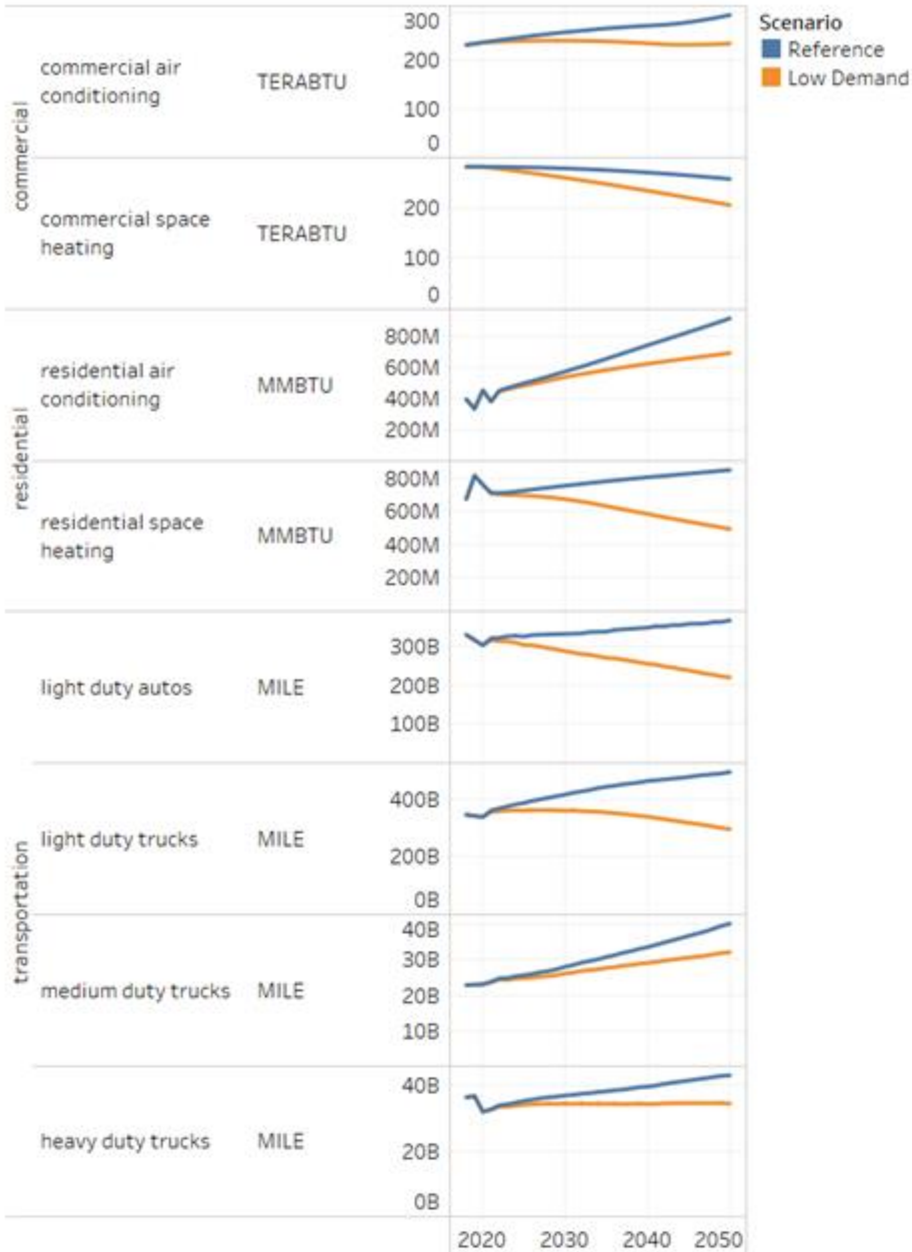


Figure A6. California's energy service demand for the largest energy consuming subsectors for the Reference and Low Demand scenarios. Scenarios not pictured have the same energy service demands as the reference case.

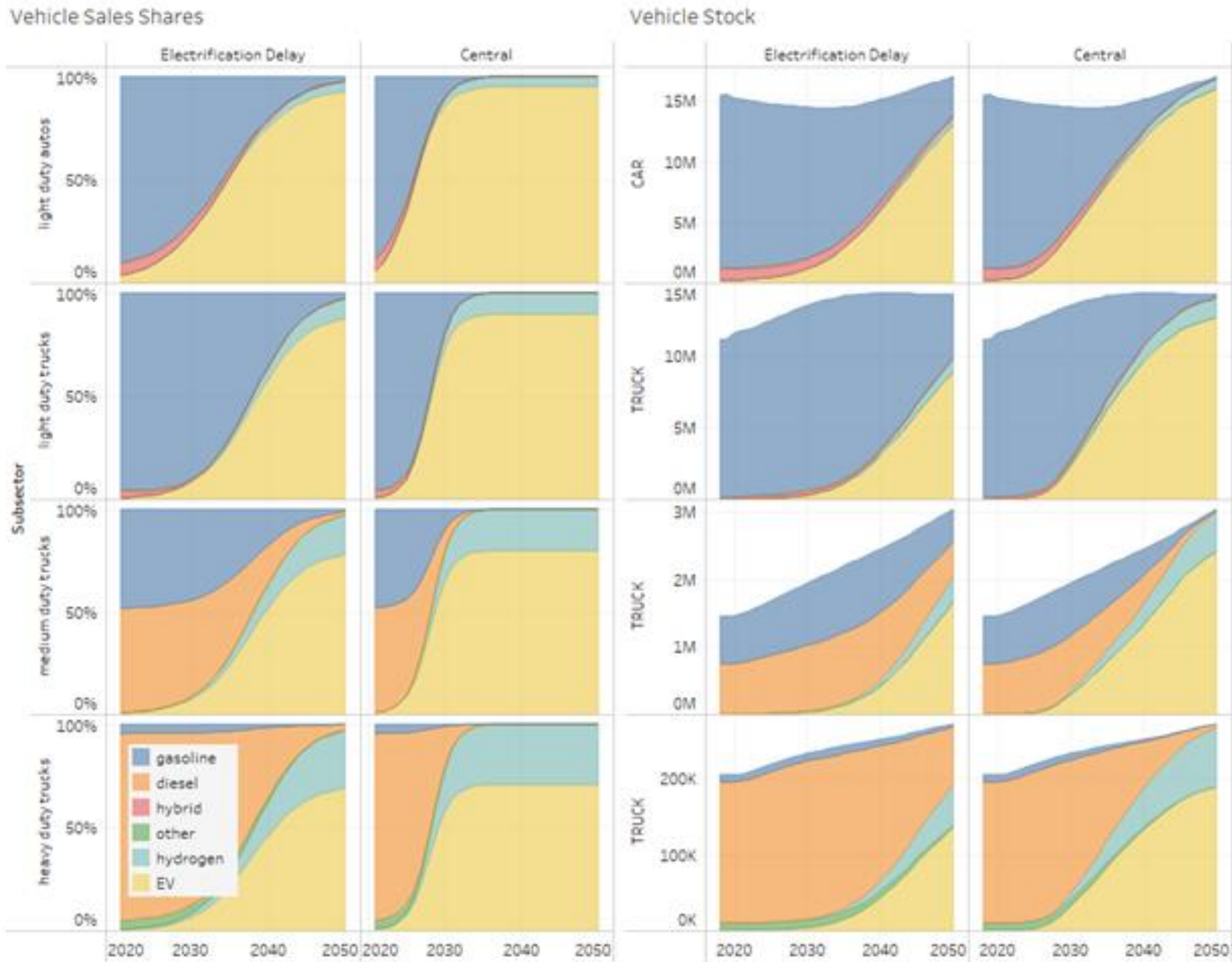


Figure A7. Vehicle sales shares and resulting stocks in California

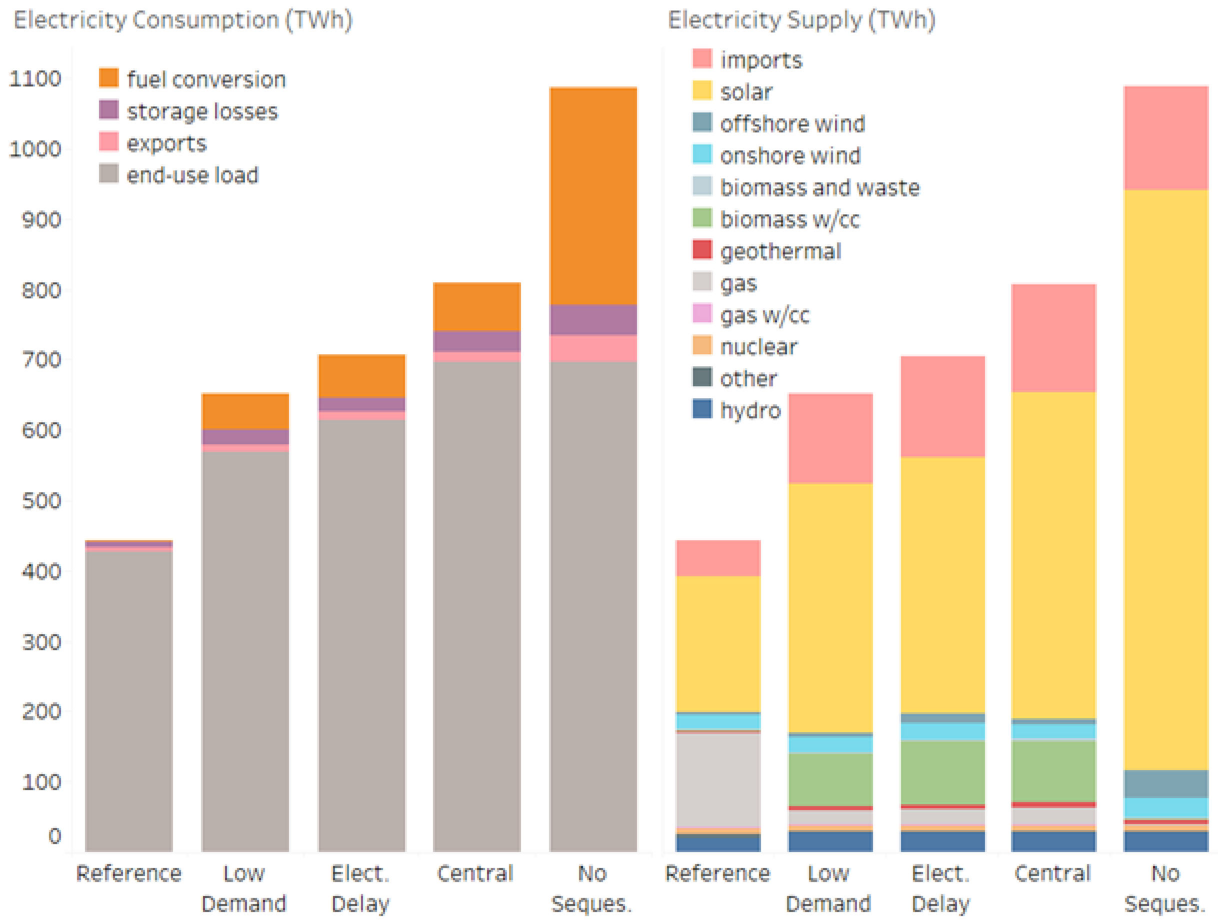


Figure A8. California 2050 electricity consumption and supply. Fuel conversion loads include both electric boilers and electrolysis.

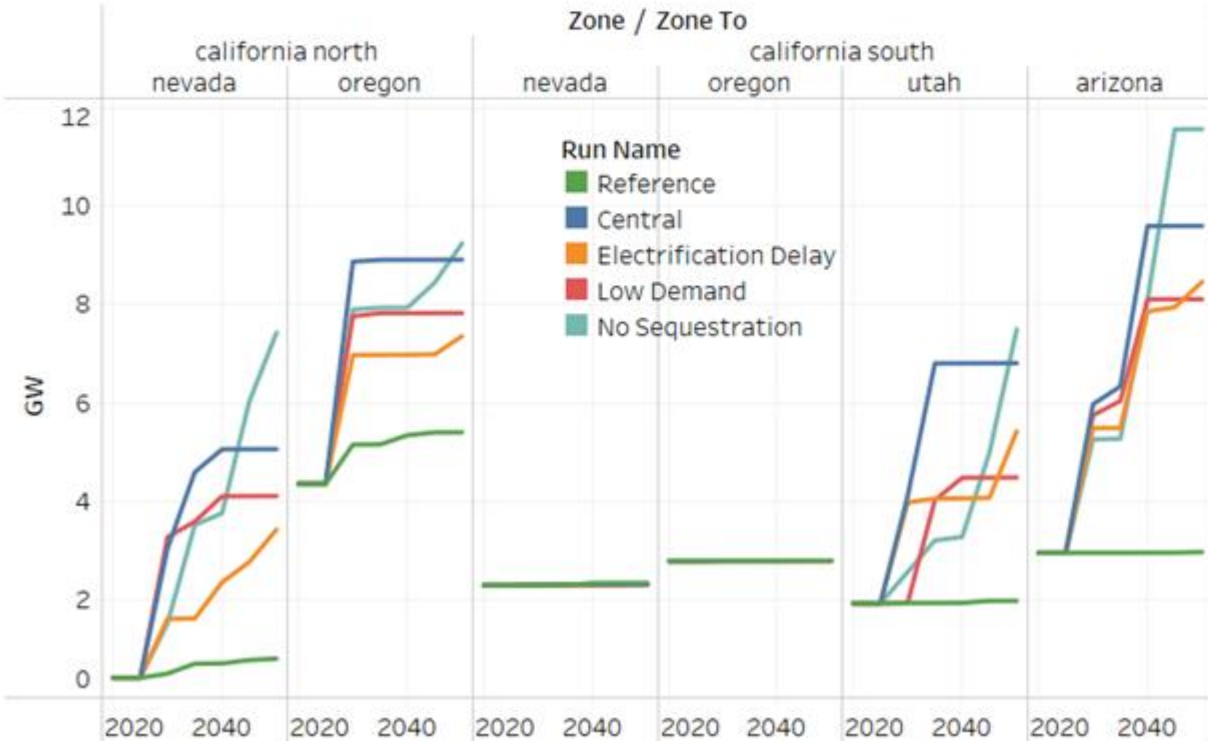


Figure A9. Transmission tie capacity from Northern and Southern California to surrounding zones.

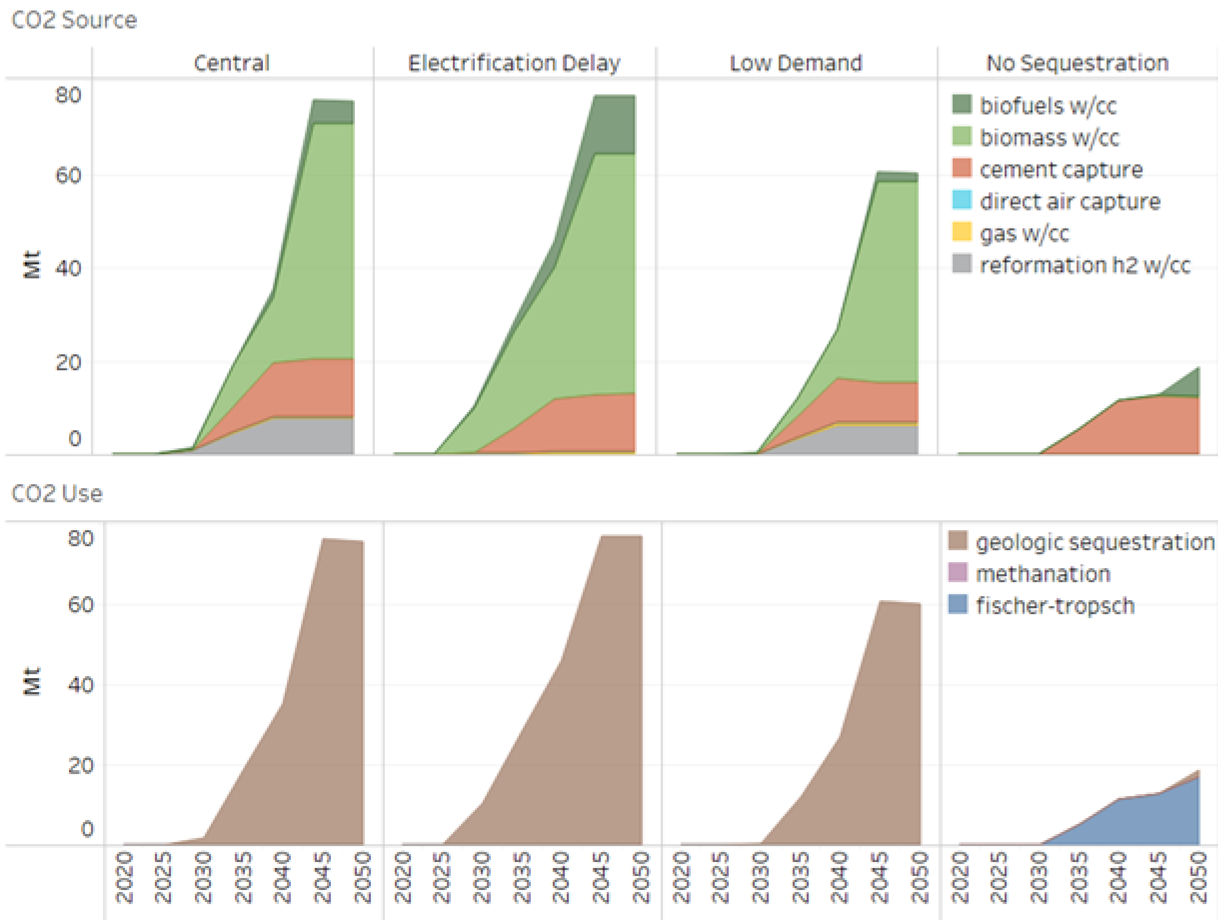


Figure A10. Capture and utilization of CO_2 in California for net-zero scenarios.

Limitations

While the EER modeling offers several robust insights about where decarbonization pathways should begin--massive electrification and renewable deployment--uncertainty makes it impossible to perfectly model the optimal trajectory, and some questions remain without a robust answer.

One important area of uncertainty not fully addressed by this modeling exercise is reliability. Electrification of end uses means greater reliance on the power grid to provide vital energy services, and large increases of intermittent renewable resources on the grid imply possibly large changes in energy system reliability over the course of the transition. While EER models do include grid structure and some temporal granularity, they plan for system reliability only 2-5 years into the future, rather than over the whole 25-30 years modeled. Thus, model results on the quantity of energy supply resources at the end of the modeling period (eg. X MW in 2050) should not be understood as directional, rather than precise measurements.

Also, regional level costs—both demand and supply-side—reported by the EER model are subject to significant uncertainty. These models are meant to estimate costs over broad geographic areas, and do not produce detailed outlines of the geographic distribution of these costs in sub-regions. The distribution of costs depends on many factors—including fuel availability, sequestration costs, and economic and population trends, among other—which are very difficult to estimate over time at a high spatial resolution. For this reason, regional analyses have treated EER model cost estimates for zones (like Southern California) as broad approximations and have not been precisely reported here in this Appendix.

Works Cited

1. Williams, J. H. *et al.* Carbon-Neutral Pathways for the United States. *AGU Adv.* **2**, e2020AV000284 (2021).
2. Larson, E. *et al. Net-Zero America: Potential Pathways, Infrastructure, and Impacts, interim report*. 345 (2020).
3. SDSN. *Zero Carbon Action Plan*. (2020).
4. Decarb America Research Initiative. Reports. https://decarbamerica.org/report/ (2021).

Appendix B. Public, Public Agency and Stakeholder Outreach

There were three parallel tracks of outreach intended for the public, public agencies and stakeholders that occurred during the development of the draft framework, between July through October.

1. Public

The County of San Diego began the public outreach process with a public notice and Board of Supervisors hearing in July. A web-page with a form and email address was created for submittal of public comments. In addition, the public could submit comments through the County Clerk as well as at the Board hearing. Public notices for all hearings and workshops were sent out to over 11,000 subscribers of the County's list that had signed up to receive emails on sustainability and climate action planning.

On September 13, 2021, the County held a virtual public workshop to kick-off the drafting of the framework. The workshop featured an overview of the project by County staff, as well as a special guest presentation by Elena Crete from the UN Sustainable Development Solutions Network. It was followed by public comments facilitated by planning consultants Moore, Iacofano and Goltsman (MIG).

2. Public agencies

All regional agencies and 18 cities were notified of the project, with an invitation to receive further information and presentations. The regional agencies included the San Diego Association of Governments, San Diego County Air Pollution Control District, San Diego International Airport Authority, and the San Diego Port Authority. All these regional agencies as well as some cities expressed interest in collaborating and working together. The Commissioners of the Port of San Diego adopted a formal resolution supporting the development of the framework. Furthermore, the California Environmental Protection Agency (CalEPA) provided support and input throughout the process.

Further collaboration and input is expected in the coming months of finalizing the framework. The regional agencies, CalEPA and the California Air Resources Board would be serving on a Technical Working Group to review this draft. Some cities and agencies have requested presentations of the draft framework to their respective decision-making bodies or committees.

3. Stakeholder Groups

Over 60 local organizations that are established in the areas of transportation and land-use, buildings and industries, and energy were invited to 6 focus groups. The list of stakeholders includes public agencies, businesses, labor, environmental and community organizations. The participants, topics and questions in these focus groups were organized based on interests and affinities in order to have a productive and substantive conversation on each of the focus group areas. These focus groups were also facilitated by MIG, and were attended by both County staff as well as some of the authors of the framework, in order to have a dialogue on the methodology and to respond to questions about the framework. Some of the stakeholders also requested individual presentations to their respective organizations, and these requests were accommodated based on availability of staff. These presentations described the process of developing the framework, and served to generate awareness of this regional effort.

FOCUS GROUPS

August 23 - 26, 2021

S U M M A R Y   R E P O R T

INTRODUCTION

Between August 23 - 26, 2021, the Land Use and Environment Group of the County of San Diego conducted six focus groups regarding the proposed Regional Decarbonization Framework (RDF) to achieve zero-carbon emissions in the region. The purpose of these focus groups was to engage local stakeholders and subject matter experts to review the purpose and scope of the RDF and hear ideas and suggestions for collaboratively developing the RDF. The focus groups were organized into three subject matter areas - building and industries, energy, and transportation and land use - to ensure a diverse representation of stakeholders and interests in the region. This report summarizes the proceedings, key findings, questions, and comments from the focus groups.

BACKGROUND

The global climate is changing and affecting our safety, health, jobs, businesses, environment, and overall quality of life in the San Diego region. As one of many responses to this crisis, the San Diego County Board of Supervisors is leading the development of a framework for a "regional zero-carbon sustainability plan" to achieve zero-carbon emissions.

The RDF is a voluntary effort to develop a long-term framework to achieve regional zero-carbon emissions. This will be the nation's first, truly localized effort and is being crafted with expertise from the UC San Diego School of Global Policy and Strategy, and the Energy Policy Initiatives Center (EPIC) at the University of San Diego School of Law. The Framework will provide science-based pathways to achieve zero-carbon emissions in the region through greenhouse gas reduction strategies across multiple sectors. In addition, the Framework will foster regional collaboration between public agencies, universities, schools, business, labor, communities, and tribes, as well as leverage resources at the state and federal levels. This effort is different from the County's Climate Action Plan, which links to the General Plan for the unincorporated communities.

These focus groups provided an early opportunity in the community engagement effort for RDF to collaborate with local subject matter experts and stakeholders across the breadth of the topic areas. The outcomes of these focus groups will assist the project team in conducting research and developing the RDF with a grounding in the regional context and conditions.

MEETING FORMAT

The six focus groups occurred across four days during the week of August 23rd, 2021, via the Zoom Web Conferencing client. Project team members organized the focus groups into three topical groupings to facilitate focused discussions on specific subject matter as follows: energy; transportation and land use; buildings and industries. Project team members assembled lists of known organizations, stakeholders, and subject matter experts from the San Diego region within these topic areas to engage in the entire RDF planning process. A selection of representative stakeholders within each topic area received an invitation to participate in a focus group. Two focus groups per topic encompassed approximately sixty (60) participants. A listing of the participants by group and topic is included at the end of this report.

Project team members from the County of San Diego and UC San Diego conducted the focus groups with facilitation and recording support from MIG, Inc. Each focus group began with welcoming remarks, an overview of the focus group format, and a brief presentation that covered the scope, purpose, and background of the project. The majority of the ninety (90) minutes of time available during each focus group where participants were asked a series of questions related to the framework and provided input to help guide the development of the framework. Participant input and comments are summarized in this report.

SUMMARY OF KEY FINDINGS

Following is a summary of key findings and themes that emerged across the topical areas of the six focus groups.

Existing Momentum and Leadership Are Strong

Several participants noted how the San Diego region is a leader in clean energy technology and solutions and there is significant momentum toward a decarbonized future.

- There is a significant amount of existing solar energy and infrastructure
- While solar energy capacity is high, overpenetration of the market is a concern
- SD Community Power, Sempra Energy, SANDAG, and SDG&E are all key partners in decarbonizing the economy
- A very engaged base of communities, stakeholders, jurisdictions, and diverse leaders will be important to the effort

Significant Vulnerabilities Could Limit the Benefits

There are vulnerable parts of the economy and community that are of concern in decarbonizing the economy. Key vulnerabilities include disadvantaged communities that disproportionately do not enjoy the same level of benefits of others, existing infrastructure needs, and workforce impacts.

- Historically disadvantaged communities will be difficult to retrofit unless there are subsidies and focused supports
- Certain buildings and specific components such as boiler systems cannot practically and/or cost-effectively be converted to electric
- The skilled labor force for existing carbon industries will need transition and training supports with wages that match or exceed current levels
- Community members who struggle to transition to an electric vehicle due a lack of infrastructure, such as charging stations at multi-family/rental housing locations

Electrification of Existing Buildings will be Difficult

Retrofitting of the existing building stock will be costly and potentially impractical in many cases. Many also noted that requiring new buildings to meet certain standards would be important to limit the number of buildings that would need to be retrofitted in the future. Starting with County/public buildings could show leadership and initiative for the rest of the region.

- Decarbonization of existing buildings is the biggest vulnerability - retrofitting existing homes using natural gas is a major challenge
- Electrification adds to the overall cost of homes, which are already quite costly and unaffordable for many community members. The housing crisis may be worsened

Many Decarbonization Strategies may be Viable

A number of participants expressed the menu of options for clean energy and decarbonization that are available in the region and nearby (i.e., pumped hydro, geothermal, solar in the built environment, microgrids, carbon sequestration, etc.)

- Solar infill in built spaces will be a potential pathway for more local energy
- Geothermal is a significant potential source of energy to use as back up
- Geothermal also presents an opportunity to transition workers from energy plants to geothermal

Community Education and Stakeholder Collaboration are Critical

The majority of participants emphasized the need for a comprehensive and robust public engagement campaign and the importance of including regional entities, such as SANDAG, SDG&E, SD Community Power and other Community Choice Aggregation (CCA) programs, school districts, and similar stakeholders.

- An education campaign with a robust curriculum can facilitate a collaborative effort with many jurisdictions
- Successful execution of the framework would need participation from SANDAG and the SD County Water Authority
- Community-based organizations can support communication and engagement with hard-to-reach, underrepresented, and environmental justice communities as trusted and credible partners
- Education and engagement materials must be culturally and linguistically relevant and accessible for diverse communities and specialized outreach methods

SUMMARY OF DISCUSSIONS

The remaining section of this report is a compilation of discussion points across all of the focus groups. Participants answered questions related to the framework and provided input to inform early efforts in developing the RDF. Responses are grouped by questions and additional comments can be found in the latter portion.

OPENING QUESTIONS

1. **Thinking of the San Diego region as a whole, are there specific factors or conditions that can make it a successful model in decarbonizing the economy?**
   - Solar - there is already a significant amount of solar energy and infrastructure in the area
   - Broaden the scope of energy supply - wind, geothermal, etc.
   - Microgrids and the co benefits (i.e., YMCA) - lowering energy costs and providing energy options at a local/hyperlocal level
   - San Diego has one of the highest insulation in the country - good site for distributing energy resources
     - Need to prevent CPUC from putting in place things that prevent distributing energy resources (in favor of remote resources) - it doesn't make sense for San Diego to import power from so far away with the availability of solar in the region
   - Microgrids are important and relevant especially for rural communities with increased fire dangers - hardening the rural distribution network (costly) vs providing microgrid and providing storage (cheaper)

- All communities in San Diego County need to move to CCAs - but they need to be reliable and efficient - also need to ensure they aren't buying energy from far away
- Region gets a lot of sun and is prime for solar, but we should also look at ensuring clean energy is highly efficient
    - All systems can be made more efficient and we can look at improving different sectors energy consumption
- Pomona University research - American West at Risk
    - Introducing green energy components within the built landscape and mitigating energy loss - co benefits of these topics (i.e., shade) and can be combined with addressing other vulnerabilities (drought tolerant and native plant landscaping) - less energy usage and water
- The San Diego region should consider forming a Regional Energy Network (REN) similar to what the rest of SoCal has.
    - https://socalren.com/about
    - Could be a separate JPA managed by or in partnership with SDCP
        - There was an effort some time ago to form one at SANDAG, but SDG&E killed the proposal.
- San Diego has a unique opportunity to address jobs and equity
- San Diego uniquely has a trade association and has been involved in many initiatives towards achieving clean energy in the region - There is strong groundwork in the area and potential for significant federal funding
- Public support and acceptance will be important in the process - education campaign
- State goals and commitments that span term limits of elected officials will help to further advance the goals of the decarbonization framework
- Decarbonization of cement and steel is a prime industry to address
- Should consider the over penetration of solar and the dot curve - Decarbonization has been expensive for individuals so local energy storage should be addressed to help solve this
- Water importing and the potential for producing more water locally in the future and storage associated creates a large increase of energy usage in the region and should be considered in advance
- Over penetration in solar is too high - we are missing out on opportunities
- Looking at decarbonization in the transportation sector and further integrating renewable resources into that sector will have a significant effect
- Subsidies to certain communities can add to rate hikes and inequities in other areas - there are many layers to decarbonizing the economy

- Will the implementation plan include solutions? How will new technologies be factored into the planning?
- If we are going to do long range planning based on modeling, then the models need to be accurate - the agricultural models are currently inaccurate - nonnative grasslands are being classified incorrectly - they need to be going to the agricultural sector
    - Dairy farmers are diverting food waste from Miramar landfill to feed cattle, but credit is given to the solid waste sector not agriculture
- Agriculture sequesters carbon and if agriculture land is removed, we would be removing carbon sequestration
- Local food is available in the region - ag, fisheries, working lands, etc.
- There is an engaged resident base and consumers that are interested in doing good
- We should think beyond the traditional climate action frameworks - look at mitigating harmful impacts and support the natural ecosystem
- Strong partnerships with those involved in conservation
    - Also, a strong emphasis on conservation within many jurisdictions
- Jurisdictions and organizations that manage natural lands are ready to jump in and participate
- Need to consider the binational nature of the economy when looking at decarbonization
- Diverse group of leadership and a community that has been thinking about decarbonization for decades - the bench is deep
- SANDAG has a very ambitious long-term plan
- Boundaries align in a lot of different ways - SANDAG, SDG&E, etc. - allows the region to coordinate quickly
- Momentum in the region to serve as a model for the state *(and country)
    - Many cities in the region have a CAP
- The political factors will have a significant impact on moving this plan forward
- Does using scientific pathways to achieve decarbonization also consider the impacts to the economy and the workforce?
- there can and should be ample employment opportunities in a decarbonizing/decarbonized regional economy. This includes employment in building: to meet regional development and housing needs, including affordable housing, Without land use sprawl
- There is less existing fossil fuel industry and workforce in San Diego, so we can look into decarbonization pathways such as entirely electric businesses and homes
    - There is a large cleantech sector and solar adoption, so there are many tech companies and places looking to be more innovative - we can leverage those

industries to help achieve decarbonization, but need to be skeptical of putting too many chips into unproven methods

- SD Community Power should be a key partner moving forward
- There is a large opportunity to put equity at the forefront of the planning process (emphasis on the EJ communities and prioritizing investments in those areas)
    - Should include the EJ community in the discussion
- Raise the work the city did on the equity index and incorporate that into the planning process
- Should also emphasize the housing affordability crisis and look at how moving away from fossil fuels can play a role in addressing the crisis
- There are so many actors in San Diego that are working towards a cleaner future and the City is doing significant work on transitioning the City to a decarbonized future
- Want to see the research and data from decarbonizing the economy and the impact that it will have on the economy - especially those south of the 8
- Need family sustaining wages and should be mindful that we do not create low wage jobs - need to create economic opportunities for all
- From a regional perspective SANDAG comes to mind since a lot of this deals with transportation - SANDAG 5 big moves and the increased focus on mass transit will have a significant impact on decarbonizing the county and economy
- The climate in the region (urban concentration near the coast) can accommodate electrification in the built environment
- History of doing climate planning (at least a decade back) and the region has a relatively small community feel - lower number of jurisdictions
- Many cities have already begun moving forward with partnering with CCAs - Encinitas reach standards for decarbonization of buildings
- There is a lot of momentum going across the region
- High concentrations of jurisdictions moving forward with community choice energy
- Lots of access to renewable energy sources that can lead towards decarbonization
- More attention to the region from the state level - opportunities for new and increased funding
- AB 617 - Port was designated
- Active building electrification coalition in the region that are addressing reach codes and other topics that are addressing decarbonization
- The collaboration within the region is great - SANDAG & SDG&E are large actors in promoting collaboration across the region and helping to address communities of concern

2. **What do you believe may be the most vulnerable parts of the economy in implementing decarbonization: sectors, business types, jobs, other aspects? How could those vulnerabilities be mitigated or solved?**
   - Timing should be considered as a vulnerability - science says time is limited but the effort will take significant time and planning to ensure decarbonization does not have negative impacts or repercussions for people in the region
   - Since we do not know the costs associated with decarbonization it is hard to identify the specific vulnerabilities
   - Housing is a significant vulnerability - especially with the ongoing housing crisis in the region
   - Existing building stock has so much sunk cost in fossil fuel systems
   - Terminal 1 in the airport can be a potential site for decarbonization, but the costs are high - this is applicable for new construction, but existing buildings need to be retrofitted which will be costly - looking forward to the cost analysis
   - Communities of concern are vulnerable to a costly decarbonization framework
   - Need to ensure we address customer choice
   - Selecting a path could create vulnerabilities in certain areas of the community
   - Owner operators of trucks and zero emission trucks are quite expensive for initial procurement costs - perhaps the small business owners will be overrun by larger businesses who have the capital to procure new technologies
   - new electricity infrastructure needed (not just the technology at the end use) requires a lot of strategic planning
   - Impacts on the communities of concern especially related to building electrification which has higher associated costs than natural gas
   - Subsidized houses will have increased energy costs when looking to electrify
   - Homebuyers are also a potential vulnerable population when looking at the increased costs of electrifying buildings
   - What type of jobs will be created in a decarbonized economy and will the green jobs be able to offer equal wages compared to the gas or fossil fuel industry
     - Just transition
     - The green energy sector is less regulated from a workforce perspective and there is not the same level of benefits
   - Construction sector is vulnerable and a sector with large energy consumption - concrete and steel takes lots of energy
     - With the movement to increase density this will be important
     - New technologies to help sequester carbon in building products
   - The existing building stock - especially the lower income owners in communities of concern - is a significant vulnerability

    - Equitable building upgrades that focus on communities of concern
- Vulnerable communities - historically disadvantaged communities - if not emphasized in solutions, can be a vulnerability. Interestingly, stopping land use sprawl will allow our economy to focus more on improvements to existing communities, esp. the CalEnviroScreen-identified communities
- Very active on building decarbonization right now (Solana Beach & Encinitas recently) - new IPCC report is a "Call to Action" to methane - cutting methane is the best strategy to slowing warming - there is a big opportunity to address aggressively cutting methane emissions
- Sempra energy is located in San Diego and there are opportunities to work collaboratively with them
- We can't forget we are a border region, and I don't see how the region can achieve 0 carbon without addressing the emissions from border crossings and the industries across the border - how will this be addressed?
- our success will be hampered if the CAPs and LAND USE PLANNING and development of all regional jurisdictions are not coordinated, and rationalized. We need to pursue policies that remove land use competition between cities and the county, and promote coordination and mutual benefit
- We need to get off fossil fuels immediately - New homes and unbuilt properties are the easy section to address, but the bulk of the properties will need retrofitting - how will this be incorporated into the plan?
- When we establish a regional sustainability plan how can we incentivize municipalities to reexamine their policies and improve upon them on a regular basis rather than a one-and-done approach
- Certain areas of the economy that are carbon heavy - goods movement, cross border, port, airport - how we can support those industries while moving towards decarbonization?
- air pollution regulations have disproportionately focused on stationary sources when they are 4% of the emissions in SD County
- Electrification of new buildings or existing buildings (or both) - has been a big concern for certain sectors (restaurants)
- Certain aspects of buildings that cannot be converted to electric - boiler systems for example - can go 90-95% electric
- Should also the economies that could be built - not just the economies that would be vulnerable
- Region is expected to be an aging population - technology and transportation can support those future vulnerable populations - transit, on demand services
- From the labor perspective - need to think about the local workers who do the work

    - Integrate language that would include local hire - PLA (project labor agreement) - especially for the commercial side (residential can be more difficult to address)
- Skilled and trained workers in the region
- Outreach to the lower income (based on Cal enviro screen) to inform them of the opportunities to develop skills within workforce development
- Coordination between the many jurisdictions and regulatory bodies can be difficult - potential vulnerability
    - Fisherman needing to change engines within a 5-year window, but there is no available technology to change to
    - Industries that don't have the level of connectivity to the regulatory side are vulnerable
- Identifying as a region - how to cut VMT - especially with the influx of businesses such as the amazon warehouse - Need to address sprawling land use patterns and the placement of goods movement now to prevent issues in the future
- I would like to reinforce the requests to prioritize impacted workers (local hire for related projects; protections/measures to support transition in industries where workers might lose jobs; etc.) and also an equity-based approach for policy recommendations, that prioritizes environmental justice communities (communities who are most environmentally burdened)
- EJ communities are overburdened and overpopulated - want to make sure the goals for the project consider equity measures to ensure no communities are left behind
    - Would like to see more representation from groups that service disadvantaged communities
- Language surrounding decarbonization is confusing - carbon draw down would make more sense - supporting the natural ecosystem and mitigating the impact on ecosystems
- We can't just think about our region - need to look at it holistically (i.e., where the cars are being produced, where goods are coming from, etc.)
- Relating to sprawl and VMT - we have many examples of residents who must drive far because they cannot afford to live in the areas where they work. We need to increase our affordable housing everywhere.
- Decarbonizing existing buildings is the biggest vulnerability - retrofitting existing homes using gas is an enormous problem with no obvious solution
- From a macro perspective the existing buildings are the biggest challenge
- Small to medium sized businesses is another vulnerable sector - lack of essential resources to retrofit

- For residential side - disadvantaged communities are the most vulnerable as they do not have the resources to retrofit
- gas workers here in the region and these efforts should identify folks whose jobs are at risk and find a way that workers can be protected from risk of job loss
- Data source - climate equity index → to identify community of concerns who may be more vulnerable
- Should be sure to be inclusive of all sectors and stakeholders
- Skilled labor groups in the fossil fuel industry are highly vulnerable - the existing jobs in the residential solar industry for example (where many skilled workers could transition to) is paid significantly less - need the pieces in place to transition these workers before we begin making the transition to decarbonization
- existing buildings are a great big challenge - many other municipalities have been trying to address the problem with limited breakthrough on best practices
    - Community cooperation will be key, and it may require some rethinking compared to what our market driven economy is used to doing
- There needs to be concrete steps in place for how the just transition will take place - it is not just a matter of equal wages - there needs to be collective bargaining and ensuring the workforce is represented through labor
- Educating the local population on what the problem is and the consequences of not addressing the issues will be important
- Lack of EV charging for renters is a vulnerable area
- Attentive to job standards and maintaining job quality → pair with job pipelines from communities of concern
- Skilled labor force - especially those working in the gas sector - how will those groups be addressed?

3. **Specific to this sector [energy; buildings and industries; transportation and land use], in what ways is the San Diego region well-positioned to advance decarbonization?**
    - There are tremendous resources available for solar in the region - residential, parking lots, and in the undeveloped areas of the county for
    - There is a shift to renewable energy, but we will be faced with the challenge of integrating renewable energy into the system without natural gas as a back up
        - There is a solid geo-thermal resource next door and potential wind use in the county and offshore (offshore does pose the potential conflict with the Navy)
    - Storage is what needs to be addressed - solar is available but not during the right times of the day

- Building transition capacity to IV has been challenging. The Sunrise Power link took forever to permit and build. Addressing transmission will be needed for baseload addition of geothermal
- Pathway to 100% clean energy through SDCP
- All communities should adopt new building codes to make new construction electric
- Job creation idea: retrofitting existing homes from gas to electric - can be absorbed by CCAs and can greatly reduce the County’s carbon footprint
- Transportation and the electrification of mass transit is one of the biggest potential pathways
- Bringing up old water heaters to more modern standards for efficiency - can be a way to transition utility workers to working in a decarbonized economy
- There are geothermal opportunities in Imperial county and can be a potential area to transition the workforce
- Encourage the County to invest in regionalizing the food system and invest in local food production
- Investing in the supply chain in the region and participating in the food economy
- Sequestering carbon in open land
- Capture emissions from specific industries such as waste and landfill
- 2021 SANDAG regional transportation plan - looking to reduce VMT
- Focus growth and development in mobility hubs
- Effort recently conducted by a group of agencies - Accelerate to Zero - A20 Collaboration - bring zero emission vehicles to region
- Gap analysis that investigated the future of integrated infrastructure specific to transportation
- San Diego can make our diverse landscapes productive (wetlands, chaparral, agriculture, etc.) and keep the land a GHG “sink”
- As always, public investment leads and promotes private sector investment, jobs, etc. Our public sectors need to invest $ in improving the already urbanized communities; infrastructure, housing, etc.
- The County should establish a robust community outreach plan that can educate people (especially the environmental justice and disadvantaged communities) on the topics of the decarbonization framework
- A grassroots outreach plan can help to address specific concerns for certain communities - i.e., transition from gas stoves to electric
    - Will also make the process more collaborative and inclusive for everyone and help to establish the coalition for the framework

- strategic changes to current State laws can promote this effort: have State housing requirements, for example, recognize a regionally coordinated efforts that meet housing needs without competitive sprawl
    - even State laws on how property taxes are collected and distributed out, can be amended
- The regional effort could allow multiple communities to come together to pursue larger grants
- There is a high saturation of solar energy and battery storage is getting cheaper
- Microgrids can create opportunities for focused decarbonization, and since it is smaller it could provide a better way of supporting vulnerable populations

a. **How would you describe that pathway? What could accelerate and/or strengthen this pathway?**
    - Need to act immediately to address climate goals
    - Any new building that isn't decarbonized will add to the buildings that will need to be decarbonized in the future - reach codes that require all electric buildings is addressing that concern
    - Alternative energy sources - such as hydrogen and blue hydrogen - are unproven and we need to be mindful of not pursuing unproven methods that could increase emissions
    - One way to start the pathway would be through municipal buildings - the County should retrofit or build new buildings that were entirely electric to show what can be done
    - amend local building codes as quickly as possible
    - San Diego is going through a transition about how to get around - if we are looking at establishing more transit and buildings in certain areas, we should prioritize the decarbonization in those areas considering they are primed to be early adopters for changes
    - We should recognize environments and equity are paramount - rather than prioritizing the views for the plan and decarbonization - Jacumba project as an example
    - Is part of the analysis of the study going to look at the potential areas for utility scale solar and other places in the region where electric energy can be stored? Local microgrids and rooftop solar is ideal, but we need to recognize the impact to workers when moving from large grid to microgrid structures
    - Looking more into the community engagement options we could talk with KPBS to partner with them to inform people about what they can do

in their own homes and how they can help people of other communities - Discover series at KPBS

- Need to pay more attention to where the decarbonized energy is coming from - i.e., solar farms disrupting pristine areas rather than more localized solar panels on roofs - also the implications of the distance the energy must travel
- Need to look more at addressing greenhouse gas emissions and capture those rather than being so focused on taking away gas cars
- Need to ensure there is a just transition - look into subsidies and incentives for electric energy options at the regional level → can focus on the key issues locally such as incorporating the existing workforce
- Need to recognize that the discussion is not just on energy - every sector is impacted by energy usage
- Just transition is important - look into a workforce impact analysis to identify the opportunities and threats for certain decarbonization ideas
- If just transition is not handled appropriately the fossil fuel industry will use the unions as fronts to delay the transition to a decarbonized economy
    - Unions will need to be included in the discussion and should have a stake at the table and it needs to happen from the start
    - Transition from the Diablo Canyon Nuclear Plant was handled well and could be used as a case study
- Developing a draft just transition framework for considerations by the public will be important
- San Diego is uniquely positioned to establish several partnerships across the region

SECTOR-SPECIFIC QUESTIONS

Participants were asked questions related to the general topic of the focus groups, which covered three sectors - Energy, Buildings & Industry, and Transportation & Land Use. Responses and input for these questions has been grouped by the sector the questions focused on.

Energy

1. **How do you weigh the pros and cons of the various strategies to develop wind and solar? Are there other renewable sources that would work for our region? [e.g., hydro/wave, geothermal energy]**
    - Pumped hydro storage facility (San Vicente)
    - Wind is not as favorable in the region compared to others

- Should look into decarbonization incentives for tribal lands as well
- Solar farms in the desert vs solar farms in the built environment - there are significant impacts with the large solar farms and energy expenses (also need to consider the long-term effects)
    - Solar in the built environment has a number of benefits and provides a tremendous amount of opportunity - especially on the larger (and underutilized) lots - schools, parking lots, etc. - potential partners and mutual benefits to working with organizations such as the school district
- Geo-thermal is a significant potential source of energy to use as back up
- Significant upgrades to storage will be critical to decarbonization
- Given environmental concerns over hydro power and water shortage, the solution for storage should be within the battery storage with good recycling plans.
- Geothermal also presents an opportunity to transition workers from energy plants to geothermal
- Pumped hydro storage with fresh and possibly salt water -
- There is also a potential for desalinization
- Should break away from being solar specific - diversify the energy options
- Solar infill in built spaces will be a potential pathway for more local energy
- Geothermal is a somewhat difficult energy source as that seems to be more direction from the state level so the County should focus more on the areas that the County has the capacity to address

2. **What are the untapped local opportunities to scale-up renewable energy generation and storage? What initiatives are already underway? [e.g., CCEs, power purchase agreements]**
    - Oregon’s wave energy facility
        - https://today.oregonstate.edu/news/construction-set-begin-month-oregon-state%E2%80%99s-wave-energy-testing-facility
    - Establish partnerships with Imperial County (geothermal & lithium extraction)
    - SDCP is developing a community power plan and needs assessment that could potentially identify sites that are primed for adding clean energy and working to decarbonization
    - solar on parking lots seem like a very good opportunity for the local government level planning efforts
    - Just to note that while projects in IID are possible (& have occurred), it is outside of the ISO interconnection system. This makes it a little bit more time consuming to approve and get off the ground than projects within the ISO service territory. Making it easier for the region could help in our decarbonization efforts

    - The ISO and the CPUC and CEC are working together to try to find ways to bring more geothermal to the grid as part of the state level Integrated Resource Plan, and as part of the CAISO Transmission Planning Process.

3. **What can the County and other cities/agencies do as an energy consumer to lead by example?**
    - County should not join a CCA without significant job quality standards - Incentivize the proper requirements up market which can help with the just transition

Buildings & Industry

1. **What are the pros and cons of the various strategies to decarbonize buildings? [e.g. electrification, zero-carbon combustion fuels, onsite renewable electricity, purchasing offsite renewable electricity, energy efficiency]**
    - again, building/electric and related codes can be an impediment, changing these codes for all jurisdictions can be a pro
    - We have the technologies available to decarbonize so we should not put too many eggs into the basket of technologies that need years to be realized
        - Focus on technologies that we have and are proven
    - We should be very wary of "greenwashing" by Sempra and the IOUs advocating for "renewable" natural gas, hydrogen. We must stop the use of fossil fuels.
    - Harnessing all available $ resources for incentives for bldg. decarbonization - not only public $, but private sector/charitable sector as well. Why not a major campaign with the SD Foundation?
    - There are a lot of uncertainties in this sector and energy is seemingly getting costlier and costlier - asking people to pay for the most expensive energy option needs to be factored in - especially since the high housing costs
    - Reach codes getting more and more intense is a con
    - Electrification adds to the overall cost of homes and homes are already so expensive, so we are only making it less accessible for people
    - Need to address existing housing stock and retrofitting those in order to make a dent in decarbonization since the new housing stock only accounts for a fraction of the number of homes and buildings in the region
    - Groups in the region can pull together pilot projects in response to grant funding opportunities (pro)
    - Cost and education associated with using new equipment and the getting people to change their behavior (con)
    - Developers may lower wages for construction workers due to the higher costs associated with electrification of new buildings

- Need to consider ALL costs associated with decarbonization - costs of homes, construction, etc. - BUT need to also consider the costs associated with NOT doing anything towards decarbonization - natural gas health concerns, fire hazards
    - Should consider all these factors when looking at decarbonization
- The CPUC cost effectiveness tests is great foundation for developing costs and benefits of various strategies and prioritizing them. But I would recommend that we do not limit ourselves to the CPUC's methodologies. The CPUC is also reviewing their requirements since existing methods can present barriers to potentially effective strategies because not all costs and benefits are properly represented.
- Partial decarbonization still leaves natural gas systems in place that leads to methane leaks, unfortunately. Methane is a much more potent greenhouse gas than CO2. The worst case estimates show that emissions from methane leaks may be as impactful as emissions from combusting natural gas in the short term. Full electrification makes a lot more sense than partial for new construction. Existing building decarbonization is going to be trickier and may have elements of partial decarbonization (burn out, etc.).
- We should use multiple tools to get the region towards decarbonization - there is a huge existing stock of buildings and homes that need to be addressed in a creative a multifaceted way - we may need to rely on lower carbon fuels to get to where we need to be

2. **Can you provide successful examples of local efforts to decarbonize buildings? [e.g., PACE program, net-metering, Title 24 reach codes, Encinitas green building ordinance]**
    - Retrofitting and electrifying existing homes is possible but difficult and there is a lack of contractors who can help with the transition so it can often fall on the homeowner, but it is possible
    - Airport as an example
    - Industrial association has accomplishments by sector - SDGBC Sustainability Awards
    - Successful examples - LEED, Vision, Park Smart - push for high performance buildings
    - CPUC organized IOUs to prepare cost effectiveness studies of different decarbonization methods
        - Applies to new construction
    - Visit BEI website - many examples of local efforts and successful examples - www.beicities.org
        - New construction side is something that cities are already moving on, but retrofitting existing buildings is still a difficult topic
    - Green and Healthy Homes Initiative - leading with clean energy and equity → provides a good context for moving existing homes to electric and decarbonized

    - https://www.greenandhealthyhomes.org/wp-content/uploads/2021-GHHI-Leading-with-equity_wp_Final.pdf
- SDCP - second largest energy provider in the state and has the opportunity to help with moving homes to an all-electric platform
    - Developing a community power plan that will determine energy needs, site planning, and hopefully incorporating incentive packages → if the County joins SDCP they will be able to help shape the plan and possibly create incentive plans for municipalities to incentivize retrofitting and electrifying homes
    - Potential point of engagement with SDCP team
- local energy codes have cost effectiveness studies, bldg. stock, etc. good source of CA statewide info. https://localenergycodes.com/
- Interfaith Social Services in North County - subsidization and incentives to install solar panels on family units - two benefits - help to address decarbonization and helps struggling families with lower energy costs
    - Should look at incentives for including electric energy options for affordable housing not just for wealthy households

3. **What role can the County play in leading by example, in decarbonizing its own facilities?**

- county can play a role by installing solar panels on ALL county-owned buildings, and on county-financed housing facilities
- If the County makes the effort to lead the way and look into subsidized costs that could help with the transition to electrification
- There needs to be more outreach to communities of concern - the costs associated with electrifying will be especially important for communities of concern
- Discussion around removing gas stoves from homes will be a MAJOR effort that needs attention
- Number of buildings in the County that are carbon neutral and there are other efforts that the County has been taking towards decarbonization
    - Studies around existing building stock and ways to get them to zero-carbon emission are also ongoing
- https://explorer.localenergycodes.com/
- have you considered what cost effectiveness criteria will be used to prioritize recommendations
    - Should think outside the box when prioritizing different strategies - we should not limit ourselves to what is produced by the public utilities commission

- Hearing what the county is doing is news to me - there needs to be more education and awareness on the decarbonization efforts
- Maybe the County can identify priority sites for retrofitting buildings and provide transparent true costs for construction that can serve as a guide for other agencies as they move forward
- Nice to see other agencies (County) lead the effort in building electrification

Transportation & Land Use

1. **How does the Regional Transportation Plan factor into decarbonizing the San Diego region?**
    - Should also consider the number of other clean transportation programs in the region that should be leveraged to support this effort - Clean car program AQSD
    - Like how SANDAG is pushing for more mass transit use
    - Need to be realistic about the fact that people will keep their cars for a long time - EV is expensive and not everyone has access to charging at their homes
    - EHC (environmental health coalition) - has been working on expanding the bus system and not getting distracted by addressing single occupancy vehicles
        - Investments in mass transit and transportation need to be increased drastically compared to what it has been, and this should be incorporated into the RTP
    - A commitment to infill development that is affordable is essential
    - While the RTP is making some great investments in the shift to multimodal transportation options - it will not make much of an impact in decarbonization in the region by 2035
        - We should be pushing for future affordable housing centered around exiting transportation hubs
        - Infill strategies and anti-displacement strategies will be critical

2. **What role do changes in transportation technology play in decarbonization in the near future? [e.g., electrification/EV infrastructure, TNCs (transportation network companies like Uber or Lyft), fuel efficiency, autonomous vehicles]**
    - Pushing more towards mass transit, but we need to have the first and last miles covered better
        - Scooters and other rental bikes have addressed some of the first and last mile needs, but we need more options
    - Industry members who participate in fleet transportation - how can we incentivize the electrification of freight and goods movement through new and innovative technologies

- Mode shift and different types of multimodal transportation options
- EV infrastructure - Need to account for renters who would be interested in switching to EV that may not be able to charge at home or have access to charging so how can we address this shortfall?
- prioritize zero-emission transit investments to get people out of their cars instead of electrifying the current car dependent system. electric cars are not sustainable because they are VERY resource intensive and destructive to the environment if we replace every car with a new electric one. Use limited resources on electric vehicle technology for buses and light rail
- I would like to reinforce what has already been said about recognizing the importance of affordable housing as part of the pathway to regional decarbonization.
- Building on what's already been said about distances that our residents drive to employment, including employment opportunities and safe active transportation infrastructure along with affordable housing and transit could help encourage a larger mode shift to lower emission forms of travel
- Advancing on demand service that are pooled or shared
- Should be considering potential vulnerable populations and how transportation technologies can serve those groups - i.e., aging population
- Vehicle grid network and clean mile standards
- Additional incentives to promote transportation technologies

3. **How can the region address the emissions from the consumption supply chain? [e.g., food supply, Port, trucks, border pollution from Mexico]**
   - Mandating certain levels of clean emissions and providing incentives for reductions of emissions at the supply chain level will be important to ensuring compliance
   - Consider federal level policy and how it would influence policies in the region
   - What can we learn from the past examples of prematurely moving towards adopting certain policies
   - Regionalize our food economy (and other aspects of the supply chain) to reduce the emissions from consumption decisions
     - Incentivize regionally available products
     - Education campaign for consumers to recognize the carbon footprint of goods movement and supply chair
     - E.g., avocados grown in Ca that are not seen here in California - most come from Mexico where the practices are more corrupt
     - There needs to be a just transition

- Water - energy use affiliated with water transport and the water cycle → we need to regionalize to mitigate the impacts associated with providing water to the region

4. **What role can the County and other cities/agencies play in leading by example, in reducing emissions from their own transportation and land-use decisions?**
   - Cities often lack funding so in order to actualize a regional plan there needs to be funding and staffing for each city
     - Funding is a major issue around the implementation side
   - Need to change our mindset - The city and County can use the narrative of the ongoing climate emergency to leverage behavior change in the region
     - Education is key
   - Advancing sequestration in natural landscapes - Much of the work that has been done has not included chaparrals
     - Urban greening has also been thrown around, but does not improve the ecosystem, so more effort should be made to protect the natural ecosystems
   - Regionally, we can repurpose existing transportation infrastructure ASAP (freeway lanes and arterials) to allow rapid, electric transit to move faster than cars and not waiting decades for new investments - transportation is ~40% of regional GHG emissions...
   - Also, the region needs to be competitive for state and federal funding/grants - County can assist with that.
   - Should recognize the good work that has been done for the framework
   - Permitting best practices for refueling clean energy infrastructure and sharing of other best practices that have been established from other jurisdictions
   - TDM programs in the region and using employers to help influence behavior change
   - California Natural and Working Lands climate strategy - looking at sequestering carbon
     - Can align the regional effort with the state and pursue grants at that level

CLOSING QUESTIONS

1. **Considering the range of stakeholders in this sector -- including public agencies, advocates, energy providers, and others -- what would a collaborative effort look like to create and implement the framework?**
   - SD Regional Climate Collaborative is good, but it doesn’t have the private sector input which can provide a very different perspective including things that may not be considered by the public sector

- Customer is the most important stakeholder in this conversation - they will feel the effects of decarbonization and increased costs
- we should acknowledge that we need solutions that achieve rapid decarbonization. This is a given. How do we select a suite of a solutions that are the most cost effective in the framework of taking action? And in cases where costs may rise (electrification retrofits without possibility for onsite PV, for example) how can we lift up the community in other ways (subsidies, wages, etc.)
- If the state passes AB 897, Regional Climate Networks will be established and can be utilized for these kinds of efforts.
- Engaging and using Community based organizations to communicate (churches, SDOP, etc.) - places that are ingrained in the community and an organization that is highly trusted
- A KPBS program (tv or radio) could interview various policy makers, talk to the public, have pros/cons, and allow people to call in and ask questions
- Within SD health is a powerful motivator to get people to act - Physicians Advisory Council - talking to the community about the health benefits of cutting natural gas
- SANDAG has had a Social Equity Working Group committee concentrating on social equity for the next RTP, and it looks like it can be continued past the year-end RTP adoption; to be an ongoing forum for this effort
- Would like to know what is already happening and what possible plans are being considered. Also, if San Diego will be modeling what they do off other cities or looking to do something new
- The more the County can share as things move forward the more opportunities there would be for engagement - bringing back this group to the discussion
    - Would like to see more back and forth between the County and local organizations
- Would like to see a “scorecard” for the County that could be put out for the average person to understand where the county stands compared to other regions
- Consider a study that would look at how the County would look like in the future if things continued course as “business as usual”
- What is the inventory of current venues for collaboration? Pull together a list of existing spaces where the conversation surrounding decarbonization and electrification is already happening
- Leverage SANDAG working groups
- San Diego Regional Climate Collaborative can also be leveraged
- When inventorying groups working within the topic, we should also look at the specific projects and work they are working on (i.e., tree planting, fire risk mitigation, etc.)

- I spoke with some of the UCSD team earlier this week about the work we've been doing at SDSU to envision a framework for nature-based solutions and we'll be sharing the info we have and a forthcoming report from our work with regional stakeholders and partners who work in the conservation and natural resource mgmt. communities
- Community important is very important and we need to ensure the engagement materials are translated and accessible for people who speak different languages
- Aligning our regional transportation goals (SANDAG) and local jurisdictions' land use patterns more effectively, while prioritizing those regional transportation investments in communities on the frontlines of the climate crisis and environmental injustice.
- There is a strong basis for regional collaboration with SANDAG - SANDAG energy working group
    - Members of the group represent a very large swath of stakeholders and can serve as a good starting point for a regional energy agency
- SD Green New Deal Alliance deserves a shout out
- Need "shovel-ready" projects so when direction comes from the federal level
- Is there any baseline data on the public opinion for decarbonization in the region
- Public opinion is shifting VERY fast. These climate disasters have drastically shifted people recalcitrance. They need to see that we have positive plans for quick moves and people will join these efforts
- Outreach will be critical - especially for lower income communities and disadvantaged communities (i.e., education on the incentives out there to add solar to homes)
- Make sure people are aware of all the opportunities to save on energy costs
- How well do the larger agencies in the region align and do they have any networks for collaboration?
    - Climate Action Plans for each agency, but no overall plan
- Identify the essentials: water, energy, housing, transportation, food systems...which agencies are leading, how can they be better coordinated, what table is best for them to sit at and work on climate mitigation, adaptation, etc.?
- The region is in somewhat required to make radical changes due to the delay in offering more clean energy options

a. **What would leadership and ongoing coordination look like?**
    - Successful execution of the plan would need participation from SANDAG and the Water Authority

- SDG&E is stepping back and offering the sale of energy to more CCAs - the CCAs become another piece of the puzzle and they have to be on board with the plan
    - There needs to be formal communication from all the necessary parties
- Identify the necessary components to rolling out this plan
- Education campaign with a robust curriculum - potential partner with school districts - to ensure a collaborative effort with many different jurisdictions
- we are fortunate to have new County Board leadership pushing this forward, and a renewed SANDAG as a forum to hash out regional coordination. SANDAG esp. can expand its traditional transportation-only focus, to raise land use coordination
- Leadership is important. It's important to have companies in our region support this effort. Disparate voices leads to confusion and non-support of the effort. AS Conor stated and I mentioned earlier the customer and customer choice is a critical input into this report.

b. **In what way could a regional climate network help shape the implementation of this framework?**
- A network could bring neighboring cities and regions together and even across the border to address emissions more holistically rather than just in the region
- If that is some version of a bulked up SANDAG, housing a regional climate network or other tables, then cities and stakeholders can engage there.
- Need to figure out where community members living in EJ communities can share their personal experiences - need to ensure they are part of the development of the plan

c. **How should regional jurisdictions/agencies communicate to ensure transparency and possible greater collaboration?**
- SANDAG is trying to embrace a more "data driven" approach to planning and making the data more accessible to all
- We could look at local carbon stocks in our landscape or projects in the region (speaks to data driven)
- Ensuring that there is a significant level of transparency and accountability - not just knowledge sharing, but actual collaboration and setting shared goals

- Not relying on the goodwill of nonprofits to participate - there needs to be a staff role for each City that would be in charge of implementation - pave the way for more paid people to actually foster change
- Transparency and accountability are very important as well as dedicated facilitation

ADDITIONAL QUESTIONS/COMMENTS

Participants provided additional comments, questions, and resources during the focus groups, as follows:

- Here is a good report put out by Gridworks, on page 18 it talks about a "PROVIDE A JUST TRANSITION FOR THE GAS WORKFORCE"
  - A good resource. https://gridworks.org/wp-content/uploads/2019/09/CA_Gas_System_in_Transition.pdf
- Here is another good report LA County that just put out by Betony Jones, from Inclusive Economics, about Building Decarbonization
  - https://drive.google.com/file/d/117bFbCLccCdu316IJAIHkRyoLMhQTQd3/view
- What is the expected timeframe for this report and the outlook?
- Is the report looking at unincorporated County?
  - County BOS initiated the effort, but it is intended to be a collaborative effort for all jurisdictions across the region - public sector and stakeholder groups
- Are there potential changes to the census regarding cities that could join the County and would that have any impact on the project?
- Overpenetration: that means the grid is not ready to take the generated renewables, so it is curtailed.
  - http://www.caiso.com/informed/Pages/ManagingOversupply.aspx
- Helpful report on a just transition towards residential building electrification. High recommend the reading
  - https://www.greenandhealthyhomes.org/wp-content/uploads/2021-GHHI-Leading-with-equity_wp_Final.pdf
- How are we thinking about the data sources and how will this project be data driven?
- Developing a mindset in our region that we are all needed in the struggle to address Climate Crisis. We can go from being divided on the need for Climate Action to being united in ways we see communities come together as they do in crisis. I don't mean we exploit the panic or fear that climate crisis creates, but certainly embrace the known unity it will create.

- as important as the construction of buildings, maybe more important, is where buildings are built - what the regional land use pattern is, correct?
- Interested in the work of land use and implications of lack of land for solar and wind usage
    - https://www.edf.org/sites/default/files/documents/SB100%20clean%20firm%20power%20report%20plus%20SI.pdf
- Want to applaud the effort of this project to not be prescriptive for the entire county
- Accelerate to Zero Emissions (a2zsandiego.com
- A summary of SDG&E's Clean Transportation initiatives and incentives can be found here: https://www.sdge.com/residential/electric-vehicles/electrification-projects-overview
- Is teleworking considered in VMT space of the RDF?
- It is included in the analysis - looking at the ability of teleworking to reduce commuting VMT
    - One interesting aspect of the reductions in VMT from the increase in teleworking has been that people are making more trips in other places - teleworking not necessarily the “silver bullet” to addressing VMT
    - https://www.kpbs.org/news/2021/aug/17/how-remote-working-has-changed-san-diego-rush-hour/
- We have a highway tracker where you can see changes during the pandemic: https://gis.sandag.org/HighwayTracker/
- CleanCities SD: https://sdcleancities.org/
- https://cleanvehiclerebate.org/eng
- https://calevip.org/incentive-project/san-diego-county
- Specific groups and other groups to reach out to:
    - Climate Collaborative: https://www.sandiego.edu/soles/hub-nonprofit/initiatives/climate-collaborative/
    - San Diego Food System Food Vision 2030 is looking to use land to fight climate change and promote racial justice https://sdfoodvision2030.org/
    - Committees and Working Groups at SANDAG: https://sandag.org/index.asp?fuseaction=committees.home
    - SDG&E Sustainability Strategy: https://www.sdge.com/sites/default/files/documents/SDG%26E%20Sustainability%20Report_0.pdf?nid-18226
    - Just leaving the link to the SANDAG Regional Plan here so it is in our collection of information: https://sdforward.com/
- https://www.sandiego.edu/soles/hub-nonprofit/initiatives/climate-collaborative/
- https://greenbusinessca.org/cityofcarlsbad

- https://cleancities.energy.gov/coalitions/san-diego

NEXT STEPS

The project team explained that the next step in the process is to conduct a public workshop on September 13, 2021.

FOCUS GROUP PARTICIPANTS

Energy Group #1

August 24, 2021, 1:00 pm - 2:30 pm

- Ana Garza-Beutz - SDG&E
- Marty Turock - Cleantech San Diego
- Nate Fairman - IBEW Local 465
- Saeed Manshadi - San Diego State University
- Samuel Worley - SDG&E
- Sebastian Sarria - San Diego Community Power
- David Grubb - Sierra Club San Diego
- Karl Aldinger - Sierra Club San Diego
- John McMillan - San Diego State University
- Carol Kim - San Diego County Building & Construction Trades Council
- Satomi Rash-Zeigler - San Diego & Imperial Counties Labor Council
- Dike Anyiwo - San Diego Regional Chamber of Commerce

Energy Group #2

August 24, 2021, 3:00 pm - 4:30 pm

- Matthew Vasilakis - Climate Action Campaign
- Judd Curran - San Diego & Imperial Counties Labor Council, AFT Guild Local 1931
- Brenda Garcia Millan - Climate Action Campaign
- Jose Torre-Bueno - Center for Community Energy
- Cristina Marquez - IBEW 569

Buildings & Industries Group #1

August 23, 2021, 2:00 pm - 3:00 pm

- Kelvin Barrios - Laborers Local 89

- Matthew Adams - Building Industry Association
- Tom Abram - San Diego Green Building Council
- Philip Gibbons - Port of San Diego
- Renee Yarmy - Port of San Diego
- Conor Paris - SDG&E
- Colleen FitzSimons - San Diego Green Building Council
- Lori Pfeiler - Building Industry Association
- Athena Besa - SDG&E
- Chad Reese - San Diego County Regional Airport Authority
- Stephen Russell - San Diego Housing Federation
- Carolina Alban-Stoughton - Carlsbad Chamber

Buildings & Industries Group #2

August 25, 2021, 10:00 am - 11:30 am

- Mary Yang - San Diego Building Electrification Coalition
- Craig Jones - SD350
- Rick Bates - UNITE HERE Local 30
- Joyce Lane - SD350
- Yusef Miller - North County Equity and Justice Coalition
- Brenda Garcia Millan - Climate Action Campaign
- Matthew Vasilakis - Climate Action Campaign
- Ann Feeney - San Diego Building Electrification Coalition
- Darwin Fishman - Racial Justice Coalition of San Diego
- Jenna Tatum - Building Electrification Institute

Transportation & Land Use Group #1

August 25, 2021, 1:00 pm - 2:30 pm

- Mackenna Kull - SDG&E
- Dean Kinports - Center for Sustainable Energy
- Natasha Contreras - SDG&E
- Robert Iezza - SDG&E
- Melanie Cohn - Biocom California
- Allison Wood - SANDAG
- Dean Kinports - Center for Sustainable Energy
- Jonathan Changus - Center for Sustainable Energy

Transportation & Land Use Group #2

August 26, 2021, 1:00 pm - 2:30 pm

- Noah Harris - Climate Action Campaign
- Diane Foote - San Diego State University Research Foundation
- Cristina Marquez - IBEW 569
- Megan Jennings - San Diego State University/Climate Science Alliance
- Dike Anyiwo - San Diego Regional Chamber of Commerce
- Brenda Garcia Millan - Climate Action Campaign
- Lucero Sanchez - San Diego Coastkeeper
- Valerie Lake - SDSU
- Kyle Heiskala - Environmental Health Coalition
- Anjleena Sahni - Center on Policy Initiatives
- Elly Brown - San Diego Food System Alliance
- Gordon McCord - UCSD
- Hannah Gbeh - San Diego County Farm Bureau

DISCUSSION QUESTIONS

1. What do you believe may be the most vulnerable parts of the economy in implementing decarbonization: sectors, business types, jobs, other aspects? How could those vulnerabilities be addressed or solved? // ¿Cuáles cree que pueden ser las partes más vulnerables de la economía a la hora de aplicar la descarbonización: sectores, tipos de empresas, empleos, otros aspectos? ¿Cómo podríanabordarse o resolverse esas vulnerabilidades?

2. Specific to transportation and land use, what types of strategies may strengthen our region's pathway to decarbonization? // En lo que respecta al transporte y al uso del suelo, ¿qué tipo de estrategias pueden reforzar el camino de nuestra región hacia la descarbonización?

3. Specific to energy, what types of strategies may strengthen our region's pathway to decarbonization? // En lo que respecta a la energía, ¿qué tipo de estrategias pueden reforzar el camino de nuestra región hacia la descarbonización?

4. Specific to buildings and industries, what types of strategies may strengthen our region's pathway to decarbonization? // En lo que respecta a los edificios y las industrias, ¿qué tipo de estrategias pueden reforzar el camino de nuestra región hacia la descarbonización?

5. What are your ideas for engaging the community in the Regional Decarbonization Framework? // ¿Cuáles son sus ideas para involucrar a la comunidad en el Marco Regional de Descarbonización?

Building & Industries Strategies / Estrategias de los edificios y las industrias

need to stop adding Microplastics, they get entrapped in Mangroves.CA DTSC is working towards regulating crumb tire releases into waterways and oceans in their 2021-2023 work plan.

How will the re-using economy be kickstarted so that commodities/goods that are already produced continue to remain in circulation until their end of life instead of discarding it.

Address overconsumption of materials by building local economies and emphasizing reuse, repair, etc.

workforce development is critical for the new sustainable economy. we do not have enough people familiar with these technologies

simple ways for building managers to save av. 10% electricity/month and "go Green." Just using non-toxic, effective water treatments in cooling towers and HVACs to remove biofilm buildup is a good place to begin.

Continued reliance on telepresence, telecommuting

Green union jobs!

Electrification provides lots of good pipefitting jobs!

important that we include a just transition so that workers can be part of green union jobs. We must transition away from fossil fuels, but include workers in that. Lots of potential green jobs!

Work together with unions and labor to transition the workforce to new sectors

need programs to support existing farmland to continue producing regeneratively or transition from conventional to regen ag, encourage new farms and support farmworkers rights and social programs that elevate their livelihoods.

need to include workers but we should not allow the workers to be used as pawns of the companies that dont want to decarbonize

Retrofitting existing buildings will be critical

must stop the burning of fossil fuels, methane gas, in our homes. There are excellent all-electric alternatives to gas furnaces, gas water heating and gas stoves. The County should mandate that all new construction and major renovations be all-electric. The County should also develop a plan to incentivize retrofits of existing buildings.

Need plug-and-play (120VAC, 20A) heat pump appliances to replace natural gas dryers and water heaters without expensive home rewiring.

We need to retrofit housing for getting gas out, including EV charging infrastructure, and solar installations. Local microgrids for resilience.

not just new buildings but also retrofitting new buildings. Note not everyone can afford an EV still and mining of rare elements for and disposable of batteries is an issue. EV not a ure all.

The City of SD and County of SD's multi-hauler trash collection services are ridiculous. Why are 10+ trash trucks going through streets and alleys to collect just 3 waste streams!? In addition to unneeded GHG emissions, trash trucks are the heaviest on the road - tearing them up causing undue infrastructure investment from jurisdictions. It also lessens the quality of life for residents. Stand up to industry to make the changes necessary to achieve all of these climate goals. While some industries will undoubtedly suffer, others will absolutely flourish. Sustainable industries should be rewarded.

Replace sprawling business parks and commercial centers with mixed-use with affordable housing.

A plumber installed my electric heat pump water heater. a low-emission climate friendly alternative to gas

water infrastructure in the County is in desperate need of work. = alternate work for gas workers?

Induction cooktops have precision control of temperature of cooking. You do not need gas stoves for that

What kind of incentives can be advocated for in this Plan to help industry transition to solar, electrical and other climate smart practices? What types of shovel ready projects can we include in the Plan to be ready when Federal infrastructure $$$ start to flow?

Technologies that should be considered on path to decarbonization while creating good union jobs during our transition- Renewable natural gas, Hydrogen, Carbon Capture Utilization & Sequestration, Geothermal & Long Duration Pump Storage, Water batteries, Hydroelectricity, & Heavy Duty Transportation Technologies

Need programs to support existing farmlands or to support the transition, as well as programs to elevate their livelihoods - Carbon sequestration could be addressed in partnership with farmers especially smaller scale farms

Retrofitting (Greening) existing buildins can be a low-cost solution that would provide jobs for the construction industry as well.

Building electrification is a key strategy - all electric on new projects - has proven to be cost effective and a durable solution

Consider mandating all new buildings need to be electric - University of California as a case study - exception process but no one has asked for it

"Natural" gas is methane. We need to stop allowing it in new construction in the county. No exceptions. There are electric alternatives for everything already available. Combined with rooftop solar makes it all very efficient

subsidize regenerative farming

Sequestration benefits of carbon farming are highly applicable in San Diego County and represent a win-win solution. As you said, incentivization and pilot projects are the path forward. SanDiego350's Food and Soil Committee strongly supports this.

Building Electrification is definitely a critical move. Solar plus electric appliances are the most efficient and cheapest, most cost equitable route. Gas prices will rise as it is phased out which places heightened burden on the last people who are left using gas.

I'd also like to recommend consideration of embodied carbon in new construction. There have been huge progress in the last few years to reduce embodied carbon in a cost effective and replicable manner. San Diego region already uses limestone/Portland cement and could be a leader in this regard.

No reason why all new homes and buildings should be net carbon zero with no off sets.

Yes! Building electrification! Stop natural gas in new construction! Why should people be exposed to air pollution when they are cooking dinner?

Just transition for the union workers

For the many jobs will be be going away, we need much retraining. But more importantly, as we go to more robot and AI work, a Univeral Basic Income would be needed.

Rebates... for gas powered Leaf blowers, lawn blowers, farm equipment. Let's protect workers and public from toxic pollution and greenhouse gases.

For employers: educate them to not require that peoplle drive in every day for no reason, for those who can work from home.

Energy Strateiges / Estrategias de energía

Water Batteries should be implemented- renewable energy sources and pumped storage power plant creates powerful storage system for flexible power supply	water battery acts as a short-term storage facility and helps maintain the grid stability.	We are still using very extractive ways to mine lithium and other minerals needed to manufacture those batteries, these mining techniques that are harming environments and indigenous communities globally	make sure that the local Lithium plant at the Salton Sea doesn't cause more environmental problems.	Reservoirs must be utulized for solar panels
Nuclear used to provide 20 percent of our electric energy, carbon- and smog-free. We have lost half of that through the mismanagement of SONGS, and now the state wants to shut down Diablo Canyon. This is going the wrong way.	Clean Energy...impacts air quality, etc.	Carbon Capture & Storage (and CCUS) are not viable tech. industry has failed to implement if successfully for more than a decade. we need to stop counting on it as a solution. natural carbon sequestration should be talked about separately.	Is there a regional effort to change oil production fields into solar or wind fields?	CCS is not a viable solution
Carbon Capture from fossil fuel plants and methane-> hydrogen are ways for the fossil fuel industry to keep extracting. We must not fall for these.	While there are no wells in San Diego, we want to buy clean energy. Conversion is upcycling the land to a higher use.	desalinization is not the answer pollutes the ocean	Incentivize electric over gas lines while promoting unions and workers	Desalination- can be double processed, the salt can be used in the new generation nuclear reactors that help process spent nuclear fuel. The newer generation nuclear reactors can give all of us zero carbon energy while cleaning our air and getting off of fossil fuels.
issues with methane a program to trace and fix pipeline leaks would be a good jobs program. Also electrification to reduce the extent of the distribution network	need to have large scale GHG sequestering projects funded by the governments that have emitted more GHGs than others. Of course, we need to improve natural sequestering, but it will not be enough to capture the GHG already accumulated and will be released.	Hydrogen from fossil fuels is NOT the answer	Nuclear energy protects air quality- zero emission clean energy. Nuclear energy's land footprint is small. Typically 1000 megawatt nuclear facility needs a little more than 1 sq mile to operate. Nuclear Energy Institute says wind farms require 360 times more land area to produce the same amount of electricity and solar photovoltaic plans require 75 times more space. Nuclear energy is extremely dense. It is about 1 million times greater than that of other traditional energy sources. 1 one inch uranium pellet is equivalent to 17,000 cubic feet of natural gas, 120 gallons of oil, or 1 ton of coal.	Agree with the comments against using CCS. Far better to just stop using/burning fossil fuels in the first place, and not depend upon removing carbon from the atmosphere after we have put it up there.
Agree with the comments against using CCS. Far better to just stop using/burning fossil fuels in the first place, and not depend upon removing carbon from the atmosphere after we have put it up there.	Electrification provides lots of good pipefitting jobs!	leaving fossil fuels in the ground	Impactful Deep Transformation is a bit nebulous. leaving GHGs in the ground is the most important.	Technology is number one by far. This is how we get increased efficiency, reduced pollution, new jobs and economic opportunities.
Yes to nuclear. Fusion in the future, fission for now.	electricity is the linchpin of decarb – we need to reduce electricity to near zero or zero co2 emissions, and massively increase the supply (probably 2X).	nuclear energy is great. too much fear mongering about a safe and clean energy source	DON'T NEED NUCLEAR!!	not possible to scale up new nuclear in the time frame we have, it takes 9 to 19 times as long as building utility scale wind or solar and at a cost over 10 times as great, Mark Jacobson, Cambridge University Press 2020.
Nuclear needs cooling. Sea level rise makes it problematic near the coast, and our reservoirs fluctuate to wildly to be safe coolant pools. Also, it takes 10-20 years to bring a plant online, and that's too slow.	we need to stop extracting fossil fuel, but also not look to use nuclear energy. Nuclear waste is radioactive, we cannot dispose the waste in a safe manner. We see that currently in Japan.	Carbon capture and hydrogen and promoted by the fossil fuel industry to keep doing the same thing.	Hydrogen is not green today; it's produced from fossil fuels	Electrification! SDSU Mission Valley committed to building their Mission Valley campus to being nearly all electric and LEED Gold building standards on the site. This required a lot of pushing but could be possible for all developers.
hydrogen and renewable natural gas are not good solutions. Stopping the burning of fossil fuels ASAP should be our approach. We are in a "Code Red for Humanity" crisis that demands immediate action.	smaller generation sites that are eltrical and available to communities	Energy efficiency and solar incentive programs, especially on bill financing and for multi-family housing	Heat pump water and space heaters, induction cooktops. These are mature technologies, and are in widespread use elsewhere in the US and overseas. No reason to use methane gas-burning appliances in the home. In addition, gas stoves produce high levels of indoor air pollution, resulting in severe health risks, especially asthma and other respiratory diseases.	roof top solar with batteries using existing distribution systems is the way to go. The sunrise power link has destroyed our viewscape and we still have power alerts and shutoffs
subsidize installation of photovoltaic solar in underserved communities, on apartment buildings, etc.; for more equity	Carbon capture is expensive, unproven technology. It is unnecessary. Existing clean energy solutions already exist	offshore wind to create not just clean energy, but green hydrogen which can be used to store energy, power ships, trains, etc	Carbon capture, utilization and sequestration (CCUS) is a false solution to climate change and dangerous distraction. We need direct emission reductions, using proven zero-emission technologies	It takes so much energy to make microchips for iPhone, EV, and others. I heard that Taiwan is building power plants to support TSMC and other companies to increase capacities. We need to make people aware of all those costs and impacts on our environment. Lots of energy and materials are used to build cars including EVs. We need to reduce our energy and material consumptions. Unless people change their behaviors, everyone will lose (very soon).

Ideas for Engaging the Community / Ideas para involucrar a la comunidad

important to emphasize is that the RDF needs to be as specific and actionable as possible, clearly outlining all of the strategies needed to achieve Zero Carbon by 2035.	What is the County and City doing to increase direct outreach to individuals and businesses to change how we live/work/eat and to put them on a path towards sustainability?	need to make sure that we're investing in our communities and ensuring a just and equitable transition	RDF must prioritize good union jobs and a jobs pipeline for working-class people of color.	The concerns about jobs/workforce must include farmworkers and the livelihood of farmers.
Too many people are still looking the other way, and running AC all day long even in the night. We need to educate them. We can buy prime TV time at multiple TV stations, and tell them how bad the climate situation is and we are the ones who is damaging this planet to "point of no return"	transformation of inequality in our society	Need to emphasize the involvement of disadvantaged communities in the process	extended producer responsibility – County could lead the way in requiring producers of products to take responsibility for the costs of managing their products (like plastics) at the end of life	Counteract deceptive messaging from fossil fuel industries
equity front and center – everyone must be allowed/ invited/helped to join or we'll never reach the tipping point to contain global temperature rise	Peope center transition includes transparency informing and involving public and creating jobs.	love the point on geopolitical cooperation and wanted to ask what you think this would look like as a strategy in San Diego. Is there an example issue where we could especially leverage geopolitical cooperation?	would like to see the county raise awareness about the negative health effects of gas stoves and offer families free or affordable alternatives	Good points about the need for outreach - on issues like building electrification, electric induction cooktops!
Need to inform the community of the increased health issues that will effect the community with the effects of climate change	Collaborate with other regional jurisdictions to address the many issues	Engage with unions to ensure we have a just transition	Climate equity has to involve advancing climate inequities and the overall goal to improve those - EJ advisory council	Utilize JEDI matrix & Justice 40
make sure Project Labor Agreements or Community Benefit agreements are part of the plan. This will protect workers, keep quality apprenticeship programs and support local labor.	focus on EJ communities and those that constitute the 'heat-islands' and often the food deserts in our communities should be a focus. There could be a very focused effort to address the vulnerability in these neighborhoods. It could include building retrofit program (job creator), increases in the urban forest, covering rooftops/parking lots/roads with solar panels (job creator). I would also recommend the County help us get rid of the energy 'wheeling' prohibition so that neighborhoods could actually create and share energy created and even perhaps an economic benefit to those residents. We need to deploy rain water capture and rain water capture (jobs) which could also support community and individual gardens through out our urban areas so they can become more resilient, food secure.	Engage young people intentionally - Climate anxiety is real and acknowledge the perception that there is not much hope for achieving change - need specific targets to reach - such as not taking fossil fuels out of the ground anymore	propose consistent sample policies for cities. For example, Escondido just voted down its Planning Commission's proposal for an Urban Greening Plan. This was a huge loss for our residents. This decarbonization plan could really offer policies and clear directions on the kinds of actions and policies that are needed in the region. If the County helped fund those actions....that would also help too!	need more public education, starting in schools if we need by-in. Because people are resisting what needs to be done already
offer compensation to people living in environmental justices communities for sharing their lived experience	an advisory committee for equity. And also for engagment: KEEP saying, publicizing, the need and the potential solutions, positive ideas, OVER and OVER again	working with community leaders in communities of concern and providing compensation for participation for those folks.	communicate hope and action! Yes many young people are resigned to climate change ending our world.	County would fund a Climate Commission and climate organizers in every city or at least in every region of the County so that there could be direct communication to city leaders from the most impacted communities. We need to develop a formal channel of communication and we don't have it now. It would be great to have the County hire youth organizers to do outreach deep into the communities.
Be honest with the communities about the changes coming to their standards of living; transportation, power usage, real property, recreation, independence and more.	engaging workers without making the solution keeping the existing jobs in tasks that need to change. The unions need to recognize that their interests are not identical to the companies.	I think it's important to work with students. We could use service-learning programs and partnerships with universities and k-12 schools.	Ask meaningful questions	SD Region should have a weekly TV or radio show that engages residents, workers, policy makers, businesses -- . Need platform for discussion and education. e.g. can interview homemakers/chefs re. induction cooktops, get input from labor, contractors, input from scientists, farmers, CCAs .... Share solutions on what we can do together and individually.
Messaging to the broader community will be critical and it needs to be understandable and accessible	Bringing in the public who doesn't typically participate will be critical	The County should emphasize the alternatives that are being brought up by the labor groups to ensure they do not lose their jobs - the County could do a comparison of existing jobs and clean energy jobs in a real way - if we cannot show the labor unions that we cannot replace their jobs with equal replacements then we will not get buyoff	Prioritizing communities of concern in electrification is key so they're not left behind or further burdened by costs they can't afford. Funding and creative solutions are needed	To engage with the community you need to talk with the planning groups who hold community meetings once a month in the community with the community
we need very much public education to undo decades of disinformation	granicus is awesome—get people on granicus, get young people on with creative content on new channels of social media (Instagram, TikTok?), give people food/things/money/appreciation when they participate	I think you should contact schools, the CBO's in the community to help spread Decarbonization because I don't think that most folks understand decarbonization!	SEQUEL is a group meeting every other Wednesday at 3 pm. Please join us!	Be honest about the effect of programs to control "climate change" on the county residents.

Transportation & Land Use Strategies / Estrategias de Transporte y al uso del suelo

Cars last 15 years. We can't get zero emissions from cars by 2035 unless we get rid of all of the internal combustion engine cars	better target is the first-occurring climate-stabilizing requirement: 80% below our 1990 emission level by 2030 - Air and Waste Management Association report	Renewable Natural Gas can have a major impact on our transportation emissions.	RNG projects capture this methane from existing food waste, animal manure, wastewater sludge and garbage, and redirect it away from the environment	how much of "land use change" GHG emissions are coming from wildfires?	Protect and enhance urban tree canopy and landscaping.
Regenerative agriculture and carbon farming can play an important role on offsetting those GHG emissions	In terms of emissions please explain land use changes	farming (specially regenerative ag and those small farms practicing carbon farming) and farmers livelihood keeps not being included in the conversations or regarded when actual solutions on this field could lead to successful strategies to achieve a Zero Carbon region by 2035.	as long as we completely stop using petroleum methane, and eliminate "natural gas" from buildings, transportation	It is possible to stop pulling fossil fuels and create a new renewable fuel that all communities can use. Not everyone can afford a new electric car, let alone a used car.	need a 32% reduction in per-capita driving with respect to 2005 (selected because this is the base year of SB 375.)
San Diego's transportation is at least 40% of our GHG, we need to have a great public transportation system that people use. Also, less sprawl and low cost housing near transportation hubs.	Cars emit way more than electricity. Cars are #1, by a lot, for our cities, our county, our state, and our country.	carbon storage and sequestration in our natural habitats—existing and restored. ReWild Mission Bay and other projects like it.	transition to electric vehicles will not happen fast enough for us to avoid disaster, we need to do more - and avoid land use sprawl creating more GHGs	need 100% of cars to be BEVs by 2030	need a schedule of how internal engine cars are phased out for new cars.
Promoting EV is promoting a new wave of consumer electronics which will help improve GDP/sale for Automotive industry but will not help sustainability.	1. When will investments be done in public transportation and when will those take fruition?	How do you ensure human and land use conflict does not arise due to deployment of solar power/wind farm/ organic compost collection?	need to reduce GHG emissions from air travels, which will hurt tourist industry.	How does air travel impact the issue?	consider a rapid transition for our public transit to all electric. Specifically our trains must go electric and they should be an anchor for our transportation. BRT will be challenging to sustainably electrify with batteries. We can and should focus on the lowest emissions most efficient solutions in electrifying transportation including ebikes which are an equitable mode much more accessible to more people. Bike infrastructure and mixed use buildings will allow people to massively lower VMT in ways electric cars will not.
Car dealers will shut down as most old makers have decided not to seriously pursue EVs in time to keep up. We should allow no new ICE vehicle dealerships	Transportation is our largest sector of emissions, and even with fully electrified transit this will remain a dominant end use of energy. The most impactful thing we can do is to increase density in areas that are already developed to prevent sprawl and reduce vehicle miles traveled. Build up, not out!	I see some fossil fuel disinformation talking points above regarding EVs and batteries. There are already recycling projects going on. This is not our problem. And lithium is not at all rare. The proper things are happening in this area.	Massively expanding public transit and link residences to jobs will be crucial. Decreasing car dependence will have enormous implications for carbon emissions.	Buy used EVs and give them to those who cannot afford buying EVs.	Policy should be focused on transportation and accessible active transportation networks
Need active anti displacement measures for people around transit hubs	need to switch to EVs ASAP through bans of ICE, new gas stations, commiting car pool lanes to ZEVs. Electricity is already getting cleaner; we just can't let SDGE stop rooftop solar, etc.	Expanding public transit and reducing dependence on cars in the region	major source of GHG is from vehicles. An essential goal should be a great transportation system with low cost housing in transportation hubs. This should be #1 in Goal-based development.	Public transportation!! So important!! The electric car cannot solve this thing	That public transportation needs to be electric too
place reduction of travel and use of energy as what we can do. It is the most cost effective. Poor people are already doing it. It's the well to do, high and middle income people who are driving up GHG emissions and pollution.	efficient public transit is key! it must be affordable and accessible to everyone.	we need more public transportation and that transportation must be near where people live and work. less sprawl, more density	End land use sprawl, insist on coupling development intensification with WORKING public transportation.	we need to invest limited resources in zero-emission mass transit to reduce dependency on cars, and to electrify heavy-duty trucks - that charging infrastructure needs to be prioritized in environmental communities first	Public transit is no help without solving the "last mile" problem. The "first mile" problem is trivial to solve with park-and-ride, bike-and-ride, etc., but if you can't get to your destination and back, public transit is useless.
we need to stop sprawl development and build more affordable housing within existing communities. We won't achieve our goals if we keep forcing people to drive long distances to carry on essential activities like shopping, working or going to school.	start addressing transportation by changing our funding system for road and freeway maintenance. Changing from fuel tax to road use fees will help reduce congestion and pollution. What we have now is not equitable.	Make public transit free to all county residences. It does not cost much. Only 30% (?) of MTS revenue is coming from ticket sales. Then increase gasoline tax and implement road use fees.	We can also take away the idea that "free parking" exist. all parking should have a price.	we need to build more missing-middle housing projects (ADUs, cottage courts, fourplexes, etc). We can look at examples from other West Coast cities like Portland, Oregon.	Improved public transportation systems must be paired with a large push to increase the number of low/no emission vehicles. And a marketing campaign to convince people that they can ditch their cars for public transport without experiencing a major loss of accessibility.
County should lead in investments into electric investment systems	need to work on our mass trans system by making it affordable so more folks can use the trolley, rail service	aviation and GHG big issue and we should be looking to impact at county level and our airports. Yes stop calling it "natural gas". It is a lot about the way we are told things are and mis communicated			

Vulnerablilities / Vulnerabilidades

Those hurt first and worst by climate change are our underserved communities	How will this apply to our neighboring county to the South? much of our carbon comes from Mexico	we need to ensure the RDF centers on equity and that it prioritizes our communities of concern	Climate Equity has to shape the plan and guide the plan for all action	necessary to achieve both GHG eliminations and equity; failure to address climate change will lead to more inequity
Defense industry has been missed out as a source of emission	Improper forest management with high tree morbidity is also causing the increases in carbon due to wild fires. The forests must be better managed to reduce impacts.	plastic carpets emitting toxic gasses is WHOLLY UNNECESSARY and must be addressed now as many are due to be removed.	Utilities they need to be bought out	PUBLIC UTIITY NOT investor owner utilities
There is not any unused empty space in the region	fossil-fuel based industries (i.e., utilities) need to transition to clean renewable energy	artificially low price of natural gas. In addition to accounting for methane leakage the natural gas system costs do not reflect the fact that system wide revenue is expected to decrease while the system maintenance costs are expected to increase to the point that rate increases would not be able to cover the expected costs	Transportation sector, meat industry.	Jobs have been a major concern including agricultural workers on front line. But also those left out of the decision making but are not considered. Need creation of safer, healthier jobs using enewable energy.
Hospitality industry might suffer if people are priced out of tourism and travel	need to look at the intersections between these issues and not silo them. As a farmer, I see the huge disconnect between food security and agricuture/working lands.	All sectors	Tourism.	a lot of industries will have worse effects from effects of the climate crisis.
food system is the most vulnerable sector on the economy,	Service sector may be most vulnerable unless the region's transportation system/infrastructuce can be radically transformed to allow service industry workers to use transit and other non-follis fuel modes.	communities that have suffered over-pollution and under-investment in San Diego are most vulnerable to climate impacts	unincorporated community of Ramona has not yet been included in the County's identification activity as a "Community of Concern" or as having a significant low-income population. 25% of our population speaks a language other than English.	Why aren't agricultural jobs ever included in green jobs? Seems like a huge oversight that I hope isn't left out of the workforce plan Supervisor Vargas was announcing.
in Descanso are in a similar situation, We have a population of lower income and ignored. Our communities are underserved in transportation accessibility, energy that is cut off, no broadband internet. We are viewed as the perfect site for these energy farms and composting sites. This gets these projects out of the city dwellers view, makes them happy and really impacts our country way of life and our biodome is greatly damaged.	If climate change isn't brought under control...no one, even union workers, will have jobs....you need to think further down the line .....7 generations	transformation of our fossil fuel economy	Just Transition for affected workers is critical because we are divided	What disadvantaged communities need for the coming future: air conditioning, air filtration, and EVs
San Diego's Barrio Logan has the third worst air quality in the state. I've been working with the community to initiate The Green Ride, an app-based electric vehicle shuttle system to address the environmental injustices that have plagued free-way and port-proximate communities for years by reducing vehicle trips, addressing parking congestion and air quality issues and ameliorate the challenges parking congestion imposes on local businesses. It can be easily replicated to create healthier, more walkable communities and then interconnect them across the region.	I dont think we should choose alternatives because they currently are employing workers. It needs to be the other way around. We need to figure out the optimal strategies and then retrain any workers who are displaced by any changeover.	restaurants will struggle in a future marked by frequent disasters and economic instability.	For every 1 cal of food produced we must use 4 x the amount of energy used to produce it - the global food supply chain is an extremely vulnerable aspect of the community	food supply risk is a huge concern. Our number one crop in San Diego is non-native landscape plants which is a bad priority.

Additional Comments / Comentarios adicionales

continued County sprawl will penalize communities, not provide the affordable housing needed, and produce more climate change GHGs	we need to keep about half of known petroleum in the ground, and 90% of coal in the ground, to keep to the Paris Accord	suggest a budget based on not crashing civilization is truly real	keep things focused.	Zero carbon is the 2nd climate-stabilizing target. It occurs in 2045, or 2050. It will not save us if we fail to achieve the first climate-stabilizing target: 80% below 1990, by 2030
US/EU have the highest cumulative GHG till date. Present conditions is a reflection of past actions. Hence its imperative that the USA step up its measure/investments/commitments to address climate change and not point fingers at China/India and developing countries on current trends. Finger pointing might score political points but does not provide solutions.	No pathway utilizing population control and then, reduction, ever appears to be emphasized It seems that population control is the "third rail" for stabilizing climate change	we are not on track to reduce GHGs to meet the goals. And it will take really huge GHG reductions to meet the <1.5C target, ec.	Carbon Sequestration is apart of Cycling carbon. Massive amounts of carbon can be pumped underground and stored in California for thousands of years to come	San Diego County has >13.85 MILLION sq feet of plastic grass playing fields emitting methane and ethylene at ever increasing amounts. It is not recyclable and ultimately is landfilled or illegally dumped where it continuers to emit these gases. They also leachate hundreds of toxic and carcinogenic chemicals- including PFAS, 6PPD, chlorinated paraffins, benzothiozoles, PAHS and more. The 13.85 million figure is exclusive of used tire playground surfaces, residential and commercial applications and more.
in the rural area of the county, our hills and meadows are being targeted for solar and wind farms. We are losing our natural open spaces to these projects. We lose our power of nature vegetation when these projects go in. The power is shut off when we have high winds and with not power we have no way to charge an electric vehicle.	Instead of large scale projects like what was just approved in Jacumba, individual solar systems need to go on roof tops of homes, buildings and parking lots throughout the county not just in solar and wind farms in our last remaining open spaces.	set up microalgae cultivation projects in bioreactors (indoors, outdoors, rooftops getting CO2 directly from chimneys, etc.) and open ponds (even on desert lands using brackish water). Microalgae absorbs 100x more CO2 than any land plant, an the biomass is used to make biofuels and renewable coproduces (materials, plastics, nutraceuticals, food, feed, etc.). San Diego has the great weather to have optimal production year-round and be an model for urban algae products.	Every year ambitions and promises are renewed but not backed by policies and progress. What is different in the County this year around? What makes these policies legally binding?	How is the County positioning itself to be the "climate leader" when SANDAG is the regional agency, the County's share of GHGs (and contributions to reductions) is perhaps only 20% (???) of the region's GHGs?
Many issues can be addressed on a regionally coordinated basis - affordable housing for example around key transportation hubs	need to be holistic and include stakeholders as much as possible	"Carbon sequestration in soils and vegetation is one of the few ways that communities can simultaneously address climate mitigation and climate resilience. Climate-smart agricultural practices (e.g., planting trees and shrubs, using compost and mulch) prevent soil erosion, increase soil fertility, and improve the soil's ability to absorb and hold water. These benefits conserve critical agricultural resources, support several County-wide efforts, including the County of San Diego Climate Action Plan, and will become increasingly important in the fight against climate change". - SD Food Vision 2030	need to also focus on short-lived climate pollutants such as methane for curbing GHGs. The Physical Science Basis of the IPCC has a new chapter of SLCP but there is little mention of this in the summary for policy makers.	pro-rating reductions
the most cherished values of our rural communities will be best served, by keeping them rural - stop urban/suburban sprawl	Stop calling it natural gas - call it methane + pollutants!	Methane was mentioned earlier in the chat, but wanted to bring it up again. Methane warms the planet 86 times as much as carbon dioxide over a 20-year period. Reducing methane emissions can provide some immediate benefits as we work on longer-term decarbonization. Reduction strategies include fixing gas pipeline leakages (or ideally reducing gas transport and utilization as much as possible), driving improved agricultural practices, and ensuring improved waste treatment and diversion, including food recovery and composting.	think the fact that we are having this discussion is a good start to hear all the voices. I do not think that today we are being presented a plan. I find fascinating that the voice of the youth is much more concern and more open to new ideas! We must be open to new possibilities.	I just want to point out that the time for the actions that we are discussing was 10 or more years ago. We are now in an emergency caused by emissions from decades ago, as i understand.
County needs to do the primary feasible mitigation measure that was proposed for both the first and second CAP	any GHG emissions contribute to the negative impacts we are seeing today, lets rally to fight climate change and get to zero emissions ASAP	CCUS can be combined with hydrogen to create clean burning synthetic fuels that every combustion engine can use without adding more carbon to the atmosphere.	CCUS created fuel can reduce greenhouse gas emissions drastically by every single combustion engine on the road today.	The UN Secretary-General did not mince words, saying that we're at Code Red for Humanity and that we must stop burning fossil fuels to do that. SanDiego350's blog on the report is here: https://sandiego350.org/blog/2021/08/13/code-red-for-humanity-a-dire-warning-from-the-ipcc-and-our-climate-action/
The best place to sequester carbon in California WAS the northern forests. Which are burning. This is one big problem: the wilder the weather the gets, the fewer chances we have to do anything about it.	San Diego risks flooding from an 1000-year Atmospheric River Storm. And due to increases in storm magnitude, we've got a 50% chance of getting hit by one of these monsters by 2050.	Legislative change includes changing State laws to replace how cities and counties are put in competition with each other, with regional coordination and cooperation	EVs do not address sustainability because the Lithium that is extracted is a rare earth mineral not as abundant as oil unless we invest in recycling lithium. Also, the GHG embedded in manufacturing (steel, cobalt, lithium, copper,aluminum mining) these vehicles need to be calculated . That said, we need to continue to emphasize public transportation over private EV cars.	Electrical vehicle batteries allow for a 3% reduction in capacity each year. For example you buy a electric vehicle, can charge 100% year 1, by year 10 it has 70-80% capacity left.
Many are interdependent. We import over 90% of our water, which informs agricultural output, thus food supply and so much more.	Address overconsumption of materials by building local economies and emphasizing reuse, repair, etc.	short term and long term recommendations on behavioral changes that can contribute to decarbonization	Disproportionate Concentration of effects in Micro Environments(People of Color)	UCSD is partnering with Cummins to recycle electric vehicle batteries then those recycled batteries will be placed in the "back up storage" to support the grid. Will they also work on recycling the nuclear spent fuel? This could create thousands of jobs, power millions of homes for hundreds of years. Nuclear energy is absolutely necessary in order to decarbonize and power the grid. 1 reactor is equivalent to 3.125 million PV panels (320 watts / panel)
Its not clear that any large sale sequestration other than natural sequestration will work at all.	consideration being given to more frequent reporting of health impacts of climate change? Climate change events are causing more severe debilitating physical and mental health conditions? People on call aware of climate change impact but many others are not. Need people to be informed so they can understand intersection and we can determine efforts to mitigate the health impacts.	Demystifying the broad reach of green collar jobs and the skills needed to fill them is critical. Let's make a concerted effort to leverage the oodles of state and federal monies available for community and economic development to provide both existing/impacted and "aspiring" professionals with training to equip them to swiftly fill the career opportunities across all sectors to support job creation, retrofitting residential and commercial buildings with energy upgrades and renewable energy improvements. Perhaps we can get some savvy grant writers and PACE (Property Assessed Clean Energy) contractors to accelerate upgrades with no up front cash in ways that will save energy, reduce energy costs for property owners, allow residents to live more comfortably and improve the energy integrity of the region's building stock. (The source of a large percentage of any municipality's emissions!)	Align what the CPUC is doing/thinking!	Goal-based development should have specific metrics and a roadmap to achieve and analyze
Come take a tour of our work on carbon sequestration and climate smart ag....solidarityfarmsd.com/tours	Aequor is in several projects with DOE. We can provide info on the many federal loans, credits, incentives for green products. mbruno@aequorinc.com	Glad this process is underway - thank you. The biggest pieces for me are 1) This must be a regional effort, with a county-wide effort to build transit, affordable housing, and a green economy. 2) It must be bold, and it must start now. We must stop kicking the can down the road. There's no mystery about what we need to do - stop sprawl development, create a functional transit system, go 100% renewable energy for all home + business needs, etc. 3) The RDF must be specific and actionable - it can't be another unenforceable aspirational target, but an actual plan. 4) It must invest in making a healthy, sustainable future for everyone - end the disparity in air quality, access to transit and housing. And it must ensure that impacted workers are fully supported and protected during the transition. Question: What is the plan for working regionally - coming up with an accountable plan that actually gets done, across the county and 18 cities? Thank you!	Some pilot projects to retrofit existing homes would be very helpful. Menlo Park is doing some interesting work in this regard, while avoiding expensive electric panel upgrades: https://www.youtube.com/watch?v=kojIFDKDtZU	The regional decarbonization framework needs to be as specific and implementable as possible so that there is a concrete pathway to actually achieve Zero Carbon by 2035. I know many of us are afraid this will end up being another document that is focused on goals and values rather than the action steps that are needed. The RDF should also include a range of provisions to secure workers' rights and livelihoods as the regional economy shifts to a Zero Carbon economy, and prioritize good union jobs along with a jobs pipeline from Communities of Concern for working-class people of color. We need metrics and concrete action steps that reflect the crisis we're in.

Additional Comments / Comentarios adicionales

This is a comment about the CA PUC. It seems to me that folks generating power with their rooftop photovoltaic systems need to be reimbursed for excess power that they put back into the grid - through the utility companies - at a more equitable rate than the meager, existing, lower-than-wholesale amounts. If we could get that up to closer to what we are charged for power, many folks would then install oversized systems..... creating a whole lot of individual electrical power suppliers with no costs other than that to the individual home system owners. The infrastructure system is already in place via the existing distribution systems already in place. This would eliminate much of the need for new transmission lines and help to reduce the use of dirty electrical generation.

San Diego County divest from fossil fuel corporations the banks and insurers that back their projects. Supervisor Vargas is on the pension board. that can happen now and stop more carbon in the air.

To end plastics pollution, laws must simply outlaw their use - esp. use-once plastics

need a plan of Towards Carbon Zero, bold, enforceable, now, and NOT "net zero" or "carbon neutral": those are excuses to do nothing now, and to rely on technological rescue in the future.

natural carbon capture should be talked about separately from technical CCS

reformed transportation infrastructure/system; new housing/development in Smart Growth areas; all new building must be zero net energy by 2030 and any sale/redevelopment project must be net zero. Finally, micro and smaller photovoltaic and wind (where feasible) facilities should be put on (financed by public funds to a reasonable degree) all buildings. Do Not defer to megascale,PV on out lands (wind facilities are much more topographic limited, but even these should not be placed in highly sensitive or rare habitat areas).

This plan was originally called a "zero carbon" plan, and the goal was to commit to zero carbon (getting off fossil fuels entirely) by 2035. I want to confirm that is still the plan? Also, along with the jobs/workforce analysis, will it also be coupled with policies to keep workers whole and ensure a just transition? Regarding centering justice and equity--will the county do outreach to working class communities of color to create policies to make sure that benefits and investments are prioritized in these communities? Lastly, this plan should be specific and actionable (we need this to be more than a high level document), and progress should also be tracked. Additionally, measures included should be coupled with a cost analysis, and ideally identify funding sources as well.

Clean transportation, storm water capture and rain harvesting, pandemic preparation and prevention, green hydrogen, fire prevention, forest restoration and protection

Healthy soils are vital for a climate action plan! We have the pesticide data from what is being used on County of SD Lands. https://cleanearth4kids.org/stop-pesticides. We need a strong County IPM! We would love to collaborate! Yes! We need a bold plan. A link to our CleanEarth4Kids.org Action Plan is on CleanEarth4Kids.org. https://cleanearth4kids.org/clean-earth-4-kids-cap

We should limit hydrogen delivery, even when we get green hydrogen, as who will have H2 pipes in their neighborhoods?

there is a pilot project in San Diego County that provides monies for lower income families to get into the EV market...then there are options for EV-PV (Electric Vehicles Powered by Photovoltaics). San Diego needs to be poised to immediately harness infrastructure monies coming out of Washington for EV modernization. The training of your workers in EV infrastructure and maintenance is terrific! If the County could be a repository for the full gamut of state, local and federal incentives available to help each citizen, business owner, laborer with assistance (incentives that inspire them to identify and act on where they fit into achieving our regional decarbonization strategy) we can really have an impact (and overcome prospective political obstacles to boot!)

encourage the purchase of more sustainable clothing; see Patagonia and Prana brands.

We also need more air quality sensors. The EPA and therefore SDAPCD has failed us here. We will not be able to measure those equity improvements.

the difference between carbon neutral and zero carbon is huge! I hope the RDF really hews to the latter

we should start building buffer zones that will reduce coastal flooding in the wake of rising seas.

creation of a panel or advisory group to oversee the development of the plan. It might be a good model that when CARB was developing the AB32 plan, there was a statewide Environmental Justice Advisory Group. It might be a good model.

Equity is also when the air quality from one part of county to another is good enough for a child to safely play outside.

Renewable natural gas, 'blue' hydrogen, and carbon capture should not be included in the RDF: these are industry strategies for keeping the carbon bubble inflated

need to be carbon negative at this point. that is why carbon capture and sequestration is so important. use nature - plant trees, apply compost and mulch. even consider planting kelp forests and restoring wetlands

I'd love to see architects design homes whose roofs can hold enough solar to charge a car once per week (4 miles driven per kWh). How about garages where there's space next to the main circuit breaker box for a house battery? How about garages under apartments that are above the local water table, so that we don't have huge amperages meeting dirty water?

Cycling carbon into and out of the atmosphere leaves carbon in the atmosphere

The County must use the RDF process to ensure continuity in substantial initiatives across the region. As an example, the move to electrify buildings (BE) - second only to transportation in GhG - will be vital to achieve our climate goals. The County could play a big role in this effort by coordinating with cities to provide access to financial and technical assistance, offer draft code language and generally promote similar practices across the region. BE will happen. A patchwork of different city regulations doesn't help developers, contractors, or homeowners. Let's include this type of support in the County plan!

Funding for pilot projects and bringing grassroots solutions to scale.

adaptation is barely off the ground in the County – cities need enormous technical and financial assistance, not to mention unincorporated areas

carbon tax would go a long way towards the goals; reduce ICE use and air travel until planes become clean

We need to stop extracting and burning fossil fuels and invest in environmental justice communities. Now.

single use plastics need to be restricted – to reduce fossil fuels and harmful waste

Revisit economic theories of prosperity definition which relies on extracting/exploiting earth, mass producing and selling it at profit for GDP growth. Example selling more cars is good for Automotive sector and is good for the GDP of USA.

Needs to be a clear plan that does not take away from workers

San Diego region has incredible potential to become a world leading clean energy and storage leader, this can create incredible work opportunities

Sealing the leaks on oil wells might be a good job, at least for a few years. Natural gas leaks, especially as we retire the pipe infrastructure, should be something we find ways to pay for.

Without Regional Integration this area will never get on track to get on decarbonization. That's currently the role that SANDAG is supposed to play (at least from the transportation system housing allocation frameworks). But SANDAG is really just the cities and county agencies, so those elected officials have to work together, not for parochial interests. They must commit to developing real (achievable, fundable, and timely/implementable) programs and projects. And that means they must put money/financing into the most effective and needed sectors (which embeds social/env. justice...).

Battery backup and installation of EV instillations has been utilized by IBEW

Why are GHGs from aircraft not included in our GHG county inventory? We have many airports located within 10 miles of low-income and disadvantaged communities. Communities have the right to know.

hope that we will seriously look into how to optimize nature-based carbon sequestration. It has some attractive by-products. It would discourage sprawl and encourage saving habitat for native species. It would probably be relatively low cost. We would probably need to improve our fire fighting capabilities, but we are going to have to do that anyway.

Policy support means, changing STate and local laws to allow aggressive regional coordination

I'm a journeywoman plumber for local 230. Its important to use a balanced approach when decarbonizing our regions. Renewable natural gas will reduce green house gas emission, divert the landfill waste, and create high-paying Union jobs. Renewable natural gas projects capture the methane from existing food waste, animal manure, waste water sludge and garbage and redirect it away from the environment while repurposing it as clean green energy sources. I support the use of Renewable natural gas, hydrogen, long duration pump storage pump storage, CCUS, and nuclear energy as excellent options for this decarbonization framework.

need to consider workers that will be affected but we should not fall for false solutions. August 2021 - New Report showing why hydrogen is a false solution for replacing fossil fuels for heating & cooking in homes & buildings.https://earthjustice.org/features/green-hydrogen-renewable-zero-emission

eliminate more carbon in the air by cutting it at the source; i.e. stop fossil fuel corporations from drilling and fracking, and putting the oil in pipelines. This stoppage can be "encouraged" by divesting from these corporations, the banks, and insurers that fund their projects. I suggest that San Diego County do that divestment in the County's Pension plan. Supervisor Vargas as a member of the SDCERA Board could look into that as part of the decarbonization plan.

setting higher gasoline taxes will help

Agree with stopping urban sprawl into the WUI....people are having home owners insurance non-renewals in the thousands in this county....their know. Municipalities need to listen!

Reduce plastics! Plastics emit methane (Dr. Sarah Jeanne Royer's discovery.) We must continue to pass Single Use plastic ordinances and work for natural grass- not synthetic turf! Great job youth for your videos!

San Francisco is doing interesting work on a plan to decarbonize large commercial buildings over a decade. Requiring a Strategic Decarbonization Assessment and timeline aligned with existing building leases and renovations.

Text from Zoom Chats during the workshops.

Time	Commenter	Comment
18:04:58	Craig Jones	Glad to see two of our Board of Supervisor members present! Very important! Thanks
18:06:06	Vice Chair, Supervisor Nora Vargas	Happy to be here!
18:07:31	Vanessa Forsythe	👍👍 thank you supervisors in attendance
18:07:48	Mike Bullock	Here is the WHY information that is provided:The global climate is changing, and we directly feel and see the effects of that change locally, in our communities, daily. This includes a higher frequency and intensity of extreme heat events, droughts, wildfires, storms and sea-level rise. Furthermore, a changing climate is causing immediate and long-term damage to our ecosystem, food production, health, safety, jobs, businesses, and our overall quality of life in the San Diego region. We need a coordinated response in our region to climate change.
18:08:09	Mike Bullock	Here is the WHY information that is provided:The global climate is changing, and we directly feel and see the effects of that change locally, in our communities, daily. This includes a higher frequency and intensity of extreme heat events, droughts, wildfires, storms and sea-level rise. Furthermore, a changing climate is causing immediate and long-term damage to our ecosystem, food production, health, safety, jobs, businesses, and our overall quality of life in the San Diego region. We need a coordinated response in our region to climate change.
18:09:57	Mike Bullock	What is NOT said about "WHY" is that humanity is currently on a path to end most life forms on Earth, includingour own species.
18:10:29	Masada Disenhouse she/her	Thank you Supervisor Vargas for your commitment to an equitable approach to reaching the zero carbon future we all need
18:11:16	J Z	Thank you, SD BOS for finally turning our county in the right direction!
18:13:04	Craig Jones	Sorry to see Sup. Vargas have to leave this discussion; please pass on to her, that continued County sprawl willpenalize her district communities, not provide the affordable housing needed, and produce more climate change GHGs
18:13:26	Cristina Marquez	Thank you Supervisors for being here!
18:14:29	Masada Disenhouse she/her	Thank you for the welcome and your leadership Sup. Lawson-Remer!

18:14:52	LYNDA DANIELS Sierra Club	Thank you! The time is NOW!
18:15:07	Cathy Gere	Yes, thank you so much Supervisor Lawson-Remer! We are grateful for your visionary leadership on this issue!
18:15:47	Luís César Modesto do Rosário Rosário	Boa noite, todas as noites a Tod@s, Saudações sustentáveis Rosário - Brasil- trabalho na Petrobras Transporte S.A. Gerencia Tecnologia . contato: luisrosario@transpetro.com.br

Time	Commenter	Comment
18:18:32	Mike Bullock	Lets get real. Cars last 15 years. We can't get zero emissions from cars by 2035 unless we get rid of all of the internal combustion engine cars that will be on the road in 2035. That would be too expensive. A better target is the first-occurring climate-stabilizing requirement: 80% below our 1990 emission level by 2030. There is a set of enforceable measures that would achieve this. They are derived and defined in a peer-reviewed Air and Waste Management Association report.
18:19:17	Craig Jones	Murtaza, you have an incredibly important and timely job: not only to take advantage of opportunities for reegional coordination between all the cities and the County, but to create and foster new opportunities aswell!
18:21:25	Craig Jones	Those hurt first and worst by climate change are our underserved communities
18:21:52	Frank Landis	As a counterpoint to Mike Bullock, we need to keep about half of known petroleum in the ground, and 90% of coal in the ground, to keep to the Paris Accord. Mike suggests an emission rate. Globally, we've got a budget that we're using up too rapidly. I'd suggest a budget based on not crashing civilization is truly real. I agree thatcars won't come off the road unless bad things happen, but bad things are already happening.
18:22:11	Mike Bullock	Dr. Baxamusa: please don't say we must "fight climate change." That is not helpful. Instead please say we must"achieve climate-stabilizing requirements".
18:23:49	Vanessa Forsythe	Mike B your constant comments in the chat are distracting.
18:23:54	Kerry FORREST	How will this apply to our neighboring county to the South? so much of our carbon comes from Mexico due to uncontrolled wild fires and of course emissions from industry and vehicles
18:25:42	Heather Hofshi	We have a plethora of our own issues to deal with, and measures we can take here in SD county, to deal with climate change without blaming another country. Let’s keep things focused.
18:25:58	Brenda Garcia Millan	I just want to second what Supervisor Vargas talked about earlier: we need to ensure the RDF centers on equity and that it prioritizes our communities of concern.

18:26:08	Mike Bullock	Zero carbon is the 2nd climate-stabilizing target. It occurs in 2045, or 2050. It will not save us if we fail to achieve the first climate-stabilizing target: 80% below 1990, by 2030. Note that this is for the industrialized nations. For all nations, the reduction can be less that 80% below 1990 by 2030. However, we are part of the industrialized world.
18:26:29	Sonja Robinson	Agree...Climate Equity has to shape the plan and guide the plan for all action
18:27:44	Craig Jones	It's certainly necessary to achieve both GHG eliminations and equit; in fact, failure to address climate change will lead to more inequity
18:29:08	Mike Bullock	Judge Taylor wrote, many yeas ago, the "enforceable measures are needed NOW. for this reason, the County needs to do the primary feasible mitigation measure that was proposed for both the first and second CAP, bythe primary plaintiff.

Time	**Commenter**	**Comment**
18:30:04	Cory Downs	any GHG emissions contribute to the negative impacts we are seeing today, lets rally to fight climate change and get to zero emissions as soon as we can
18:31:46	Kori Ellis	CCUS can be combined with hydrogen to create clean burning synthetic fuels that every combustion engine canuse without adding more carbon to the atmosphere. CCUS created fuel can reduce greenhouse gas emissions drastically by every single combustion engine on the road today. If we clean the fuel at the pump, imagine the impact we can make.
18:31:51	Masada Disenhouse she/her	The UN Secretary-General did not mince words, saying that we're at Code Red for Humanity and that we muststop burning fossil fuels to do that. SanDiego350's blog on the report is here: https://sandiego350.org/blog/2021/08/13/code-red-for-humanity-a-dire-warning-from-the-ipcc-and-our-climate-action/
18:32:25	Masada Disenhouse she/her	It hasn't been a question for many decades now ...
18:35:00	Kori Ellis	Renewable Natural Gas can have a major impact on our transportation emissions. RNG- derived from animal and land waste, RNG harnesses methane, which is a naturally occurring, but potent and dangerous GHG. Renewable Natural Gas projects capture this methane from existing food waste, animal manure, wastewater sludge and garbage, and redirect it away from the environment, repurposing it as a clean, green energy source.
18:35:11	Sonja Robinson	Can you explain this chart a little more?
18:35:49	Frank Landis	Cycling carbon into and out of the atmosphere leaves carbon in the atmosphere. We need to keep putting out GHGs and get them out as fast as possible.
18:36:09	Frank Landis	One question for the IPCC: how much of "land use change" GHG emissions are coming from wildfires?

18:36:36	Prasad Naga	What is missing in the graph from Elena is that the US/EU have the highest cumulative GHG till date. Presentconditions is a reflection of past actions. Hence its imperative that the USA step up its measure/investments/commitments to address climate change and not point fingers at China/India and developing countries on current trends. Finger pointing might score political points but does not provide solutions.
18:36:37	Frank Landis	Stop putting out GHGs, not keep putting them out.
18:36:39	Craig Jones	Right, Kori, as long as we completely stop using petroleum methane, and eliminate "natural gas" from buildings, transportation, etc.

Time	Commenter	Comment
18:36:39	Tim Snyder	No pathway utilizing population control and then, reduction, ever appears to be emphasized. It seems that population control is the “third rail” for stabilizing climate change. But if it is people that need production of GHGs, then less people would produce less? Seems simple. A lot of these graphics look to echo population growth. But population growth is sacred and no one addresses reducing the human load on this planet.
18:36:42	Ellee Igoe	Regenerative agriculture and carbon farming can play an important role on offsetting those GHG emissions
18:36:42	Bill Tippets	I think it basically showed that we are not on track to reduce GHGs to meet the goals. And it will take reallyhuge GHG reductions to meet the <1.5C target, ec.
18:36:44	Kori Ellis	Carbon Sequestration is apart of Cycling carbon. Massive amounts of carbon can be pumped underground and stored in California for thousands of years to come
18:37:09	Vanessa Forsythe	In terms of emissions please expalin land use changes
18:37:09	Ellee Igoe	It seems like farming (specially regenerative ag and those small farms practicing carbon farming) and farmers livelihood keeps not being included in the conversations or regarded when actual solutions on this field could lead to successful strategies to achieve a Zero Carbon region by 2035.
18:37:26	Dianne Woelke	San Diego County has >13.85 MILLION sq feet of plastic grass playing fields emitting methane and ethylene at ever increasing amounts. It is not recyclable and ultimately is landfilled or illegally dumped where it continuersto emit these gases. They also leachate hundreds of toxic and carcinogenic chemicals- including PFAS, 6PPD, chlorinated paraffins, benzothiozoles, PAHS and more. The 13.85 million figure is exclusive of used tire playground surfaces, residential and commercial applications and more.
18:37:45	Frank Landis	The best place to sequester carbon in California WAS the northern forests. Which are burning. This is one bigproblem: the wilder the weather the gets, the fewer chances we have to do anything about it.
18:37:57	Kori Ellis	Craig, I agree. It is possible to stop pulling fossil fuels and create a new renewable fuel that all communities can use. Not everyone can afford a new electric car, let alone a used car.
18:38:12	Bill Tippets	Vanessa, I think it means converting natural lands/habitats to developed or ag lands.
18:38:36	Vanessa Forsythe	Thank you Bill

Time	Commenter	Comment
18:38:37	Mike Bullock	What I am saying is that the measure needs to be done, ASAP without waiting for some process, like this effort or like the CAP effort. The measure was well defined by the plaintiff, in both lawsuits. It is about a needed car- parking system. The system, once it is implemented by the vendor, would be requested by others that have carparking. So here are the steps: write a RFP-supporting document and use it to award the project of designing the defined system, implementing, it and operating it to a successful implementation. "Successful" means it is favored by most of the employees. When that is done, other employers will want the system. The very same system will work downtown, for beach parking, for shopping centers, for parking-meter parking, and for pay station parking. The key to keep in mind is that even employees that drive everyday will earn more money. Of course those that can get to work without driving, at least some time, will earn significantly more money.
18:38:50	David Harris	Kori Ellis- Thanks for sharing the fossil fuel industry perspective. Have seen you message in a lot of SDGEadvertising
18:39:09	J Z	I'm not sure that this audience needs many reasons for why we need to pay attention to climate change.
18:39:18	Cathy Gere	^^^
18:39:20	Frank Landis	Also, San Diego risks flooding from an 1000-year Atmospheric River Storm. And due to increases in storm magnitude, we've got a 50% chance of getting hit by one of these monsters by 2050. An ARkStorm is the equivalent of three feet of rain in a month hitting San Diego.
18:39:21	Dianne Woelke	You mean like the remaining last sliver of Mediterranean climate Ag land in the country that developers are trying to take over?
18:39:52	Judi Schlebecker	Since in San Diego’s transportation is at least 40% of our GHG, we need to have a great public transportationsystem that people use. In addition less sprawl by be willing to have lower cost housing near transportation hubs.
18:39:56	Prasad Naga	Defense industry has been missed out as a source of emission.
18:40:04	Brenda Garcia Millan	I think what’s important to emphasize is that the RDF needs to be as specific and actionable as possible, clearly outlining all of the strategies needed to achieve Zero Carbon by 2035.
18:40:40	Kori Ellis	David Harris- I believe you have me confused with someone else. I haven't seen any SDGE advertising.
18:40:42	Ana Serrano (she/ella)	I completely agree Prasad
18:40:52	Mike Bullock	Cars emit way more than electricity. Cars are #1, by a lot, for our cities, our county, our state, and our country.
18:40:52	Courtney Ransom	Agree, Brenda!
18:41:37	Andrew Meyer	Glad they are mentioned carbon storage and sequestration in our natural habitats—existing and restored. ReWild Mission Bay and other projects like it.

Time	Commenter	Comment
18:42:59	Craig Jones	NOTE: the trasition to electric vehicles will not happen fast enough for us to avoid disaster, we need to do more - and avoid land use sprawl creating more GHGs
18:44:05	Kori Ellis	Water Batteries should be implemented- renewable energy sources and pumped storage power plant creates powerful storage system for flexible power supply. The water battery acts as a short-term storage facility andhelps maintain the grid stability.
18:44:06	Bea Alvarez - Carbon Sink Farms	We are still using very extractive ways to mine lithium and other minerals needed to manufacture those batteries, these mining techniques that are harming environments and indigenous communities globally
18:44:37	Mike Bullock	We need 100% of cars to be BEVs by 2030. We need a schedule of how internal engine cars are phased out fornew cars. We still need a 32% reduction in per-capita driving with respect to 2005 (selected because this is the base year of SB 375.)
18:45:38	Dianne Woelke	we need to stop adding Microplastics, they get entrapped in Mangroves. CA DTSC is working towards regulating crumb tire releases into waterways and oceans in their 2021-2023 work plan.
18:46:09	Judi Schlebecker	Bea Alvarez let’s make sure that the local Lithium plant at the Salton Sea doesn’t cause more environmental problems.
18:46:12	John Eldon	Protect and enhance urban tree canopy and landscaping.
18:46:12	Kori Ellis	Electrical vehicle batteries allow for a 3% reduction in capacity each year. For example you buy a electric vehicle, can charge 100% year 1, by year 10 it has 70-80% capacity left.
18:46:16	Prasad Naga	EVs do not address sustainability because the Lithium that is extracted is a rare earth mineral not as abundantas oil unless we invest in recycling lithium. Also, the GHG embedded in manufacturing (steel, cobalt, lithium, copper,aluminum mining) these vehicles need to be calculated . That said, we need to continue to emphasize public transportation over private EV cars.
18:46:19	Craig Jones	Legislative change includes changing State laws to replace how cities and counties are put in competition with each other, with regional coordination and cooperation
18:46:36	Masada Disenhouse she/her	What I didn't hear: We need to stop extracting and burning fossil fuels and invest in environmental justice communities. Now.
18:46:51	Kerry FORREST	I live in the rural area of the county, our hills and meadows are being targeted for solar and wind farms. We are losing our natural open spaces to these projects. We lose our power of nature vegetation when these projects go in. The power is shut off when we have high winds and with not power we have no way to charge an electricvehicle. Instead of large scale projects like what was just approved in Jacumba, individual solar systems need to go on roof tops of homes, buildings and parking lots throughout the county not just in solar and wind farms in our last remaining open spaces.

Time	Commenter	Comment
18:47:00	Marilyn Bruno	We set up microalgae cultivation projects in bioreactors (indoors, outdoors, rooftops getting CO2 directly fromchimneys, etc.) and open ponds (even on desert lands using brackish water). Microalgae absorbs 100x more CO2 than any land plant, an the biomass is used to make biofuels and renewable coproduces (materials, plastics, nutraceuticals, food, feed, etc.). San Diego has the great weather to have optimal production year-round and be an model for urban algae products.
18:47:21	Adam Aron	Agree with Masada, we need to stop extracting and burning fossil fuels. Now. IEA 2021 said no new fossil fuel extraction.
18:47:31	Craig Jones	The way to overcome uncertainties: exercise the will to act. Where there is the will, there IS the way!
18:47:53	Prasad Naga	Promoting EV is promoting a new wave of consumer electronics which will help improve GDP/sale for Automotive industry but will not help sustainability.
18:48:10	Kori Ellis	If the electrical vehicle batteries are lithium and can lose capacity each year, even while not in use, imagine what happens to the lithium battery storage. This will not sustainable if the capacity factor is decreased every year.
18:48:16	LYNDA DANIELS Sierra Club	Reservoirs must be utulized for solar panels
18:49:09	Mike Bullock	We need a plan, for each type of emission. Yes, as the plan is implemented we will learn and change our plan. However, we need to start with a plan.
18:49:14	LYNDA DANIELS Sierra Club	BE means building without gas lines!
18:49:21	John Eldon	Nuclear used to provide 20 percent of our electric energy, carbon- and smog-free. We have lost half of that through the mismanagement of SONGS, and now the state wants to shut down Diablo Canyon. This is going the wrong way.
18:49:34	Prasad Naga	Questions to the panelists: 1. When will investments be done in public transportation and when will those take fruition? 2. How will the re-using economy be kickstarted so that commodities/goods that are already produced continue to remain in circulation until their end of life instead of discarding it. 3. What is the County and City doing to increase direct outreach to individuals and businesses to change how we live/work/eat and toput them on a path towards sustainability? 4. Every year ambitions and promises are renewed but not backed by policies and progress. What is different in the County this year around? What makes these policies legally binding? 5. How do you ensure human and land use conflict does not arise due to deployment of solar power/wind farm/organic compost collection?
18:50:33	Sonja Robinson	Other: Clean Energy...impacts air quality, etc.
18:50:34	Craig Jones	MAny MORE THAN THREE RESPONSES APPLY!
18:51:16	Katie Meyer	Yeah I'm concerned about all of these

Time	Commenter	Comment
18:51:20	Pamela Heatherington	My 'other' is all the above.?
18:51:33	Masada Disenhouse she/her	Not listed: increased infectious disease
18:51:39	Bill Tippets	How is the County positioning itself to be the "climate leader" when SANDAG is the regional agency, the County's share of GHGs (and contributions to reductions) is perhaps only 20% (???) of the region's GHGs?
18:51:41	Terri Steele	I agree with Craig. Many are interdependent. We import over 90% of our water, which informs agricultural output, thus food supply and so much more.
18:51:45	Kerry FORREST	Improper forest management with high tree morbidity is also causing the increases in carbon due to wild fires. The forests must be better managed to reduce impacts.
18:52:03	Dianne Woelke	>13.85 million _+ other sq feet of plastic carpets emitting toxic gasses is WHOLLY UNNECESSARY and must be addressed now as many are due to be removed.
18:52:16	Jose Torre-Bueno	Utilities they need to be bought out
18:52:50	LYNDA DANIELS Sierra Club	PUBLIC UTIITY NOT investor owner utilities
18:52:52	Craig Jones	Vulnerabilties: all of the above
18:52:52	Karl Aldinger	Carbon Capture & Storage (and CCUS) are not viable tech. industry has failed to implement if successfully formore than a decade. we need to stop counting on it as a solution. natural carbon sequestration should be talked about separately.
18:53:02	Anne Sheridan	Address overconsumption of materials by building local economies and emphasizing reuse, repair, etc.
18:53:05	Sonja Robinson	fossil-fuel based industries (i.e., utilities) need to transition to clean renewable energy
18:53:09	Susan Freed	workforce development is critical for the new sustainable economy. we do not have enough people familiar with these technologies
18:53:09	Cory Downs	One issue that would be helpful to address is the artificially low price of natural gas. In addition to accounting for methane leakage the natural gas system costs do not reflect the fact that system wide revenue is expected to decrease while the system maintenance costs are expected to increase to the point that rate increases would not be able to cover the expected costs.
18:53:12	Clemencia Pinilla	It will be great to have short term and long term recommendations on behavioral changes that can contribute to decarbonization
18:53:15	Marilyn Bruno	There are simple ways for building managers to save av. 10% electricity/month and “go Green.” Just using non-toxic, effective water treatments in cooling towers and HVACs to remove biofilm buildup is a good place tobegin.
18:53:19	Mike Bullock	My first "other" is "a devastating collapse of the human population", meaning we will, for the most part, starve to death.

Time	Commenter	Comment
18:53:19	Jose Torre-Bueno	agree that CCS is not a viable solution
18:53:30	Bee Mittermiller	The fossil fuel industry will be fighting our efforts every step of the way
18:53:31	Kori Ellis	UCSD is partnering with Cummins to recycle electric vehicle batteries then those recycled batteries will be placed in the "back up storage" to support the grid. Will they also work on recycling the nuclear spent fuel? Thiscould create thousands of jobs, power millions of homes for hundreds of years. Nuclear energy is absolutely necessary in order to decarbonize and power the grid. 1 reactor is equivalent to 3.125 million PV panels (320 watts / panel)
18:53:35	Prasad Naga	Transportation sector, meat industry.
18:53:44	Peter Zahn	Some brief comments:
18:53:54	Adam Aron	Agree with Karl. Carbon Capture from fossil fuel plants and methane-> hydrogen are ways for the fossil fuel industry to keep extracting. We must not fall for these.
18:54:01	Vanessa Forsythe	Jobs have been a major concern including agricultural workers on front line. But also those left out of the decision making but are not considered. Need creation of safer, healthier jobs using enewable energy.
18:54:13	Peter Zahn	Some brief comments:
18:54:20	Yusef Miller Cleanearth4kids and NSDC-NAACP	Other= Disproportionate Concentration of effects in Micro Environments(People of Color), which preventsoverall progress towards 100
18:54:25	John Eldon	Meat industry is indeed part of the GHG problem. Go vegan.
18:54:32	Bee Mittermiller	Hospitality industry might suffer if people are priced out of tourism and travel
18:54:42	Toshi Ishihara	We need to reduce GHG emissions from air travels, which will hurt tourist industry.
18:54:56	Ellee Igoe	We need to look at the intersections between these issues and not silo them. As a farmer, I see the huge disconnect between food security and agricuture/working lands.
18:54:59	Tim Snyder	One vulnerable industry: Tourism.
18:55:01	Katie Meyer	Lots of industries, but also a lot of industries will have worse effects from effects of the climate crisis.
18:55:06	Bea Alvarez - Carbon Sink Farms	food system is the most vulnerable sector on the economy, with climate patterns changing, farming is even riskier. We need to support local regenerative farms implementing carbon farming practices and feeding our communities.
18:55:11	John Eldon	Continued reliance on telepresence, telecommuting, etc.
18:55:35	Bill Tippets	The Service sector may be most vulnerable unless the region's transportation system/infrastructuce can be radically transformed to allow service industry workers to use transit and other non-follis fuel modes.
18:55:50	John Eldon	Re: conversion of nonproductive oil fields to solar -- Nature Conservancy is doing this with a defunct coal field.
18:55:57	Jose Torre-Bueno	There are relatively few wells in SD

Time	Commenter	Comment
18:56:02	Frank Landis	Sealing the leaks on oil wells might be a good job, at least for a few years. Natural gas leaks, especially as we retire the pipe infrastructure, should be something we find ways to pay for.
18:56:15	John Eldon	Thank you Frank! Seal the leaks in our NG system!
18:56:26	Kyle Heiskala, Environmental Health Coalition	communities that have suffered over-pollution and under-investment in San Diego are most vulnerable to climate impacts. These communities have suffered bad air quality, lack f green space, housing unaffordabilityand are most vulnerable to climate impacts. these environmental justice communities of City Heights, Logan, Southeast, National City, San Ysidro need to be invested in FIRST.
18:56:33	Robin Joy Maxson	The unincorporated community of Ramona has not yet been included in the County's identification activity as a "Community of Concern" or as having a significant low-income population. 25% of our population speaks a language other than English.Our community incudes a significant workforce that does not translate into a work-from-home setting. Many of our residents must commute to work with their tools and materials to job sites. Or, they must be on the jobsite to provide direct healthcare services.When will the County recognize the vulnerable residents of our community and include them (reach out to them) in the planning of decisions that will directly affect their future and livelihood?Thank you.Robin Joy Maxson, Chair, Ramona Community Planning Group
18:56:45	Bea Alvarez - Carbon Sink Farms	“Carbon sequestration in soils and vegetation is one of the few ways that communities can simultaneously address climate mitigation and climate resilience. Climate-smart agricultural practices (e.g., planting trees andshrubs, using compost and mulch) prevent soil erosion, increase soil fertility, and improve the soil’s ability to absorb and hold water. These benefits conserve critical agricultural resources, support several County-wide efforts, including the County of San Diego Climate Action Plan, and will become increasingly important in the fight against climate change”. - SD Food Vision 2030
18:56:57	Pamela Heatherington	While there are no wells in San Diego, we want to buy clean energy. Conversion is upcycling the land to a higher use.
18:58:00	Mary Yang	We need to also focus on short-lived climate pollutants such as methane for curbing GHGs. The Physical Science Basis of the IPCC has a new chapter of SLCP but there is little mention of this in the summary for policy makers.
18:58:04	Adam Aron	Great points Jack!
18:58:05	LYNDA DANIELS Sierra Club	desalinization is not the answer pollutes the ocean1
18:58:15	Prasad Naga	👏👏👏👏
18:58:15	Anne Sheridan	Absolutely agree with Jack on pro-rating reductions!
18:58:18	Cathy Gere	I so agree with Jack about the timeline!!
18:58:20	Rick Bates	Great points, Jack!

Time	Commenter	Comment
18:58:23	Masada Disenhouse she/her	Covid just showed us how disasters exacerbate income inequality and mean that disadvantaged communities will be put even more at risk. Climate impacts will do the same thing. We need to make sure that we'reinvesting in our communities and ensuring a just and equitable transition
18:58:27	Mary Yang	Environmental Research Letters - All-out, rapid effort to slash methane emissions can eliminate 2030 emissions by 50%, slow warming rate over next few decades by > 25% & prevent ~around 0.25(°C) of additional warming in 2050 and 0.5(°C) in 2100. (May 4, 2021) Global Methane Assessment - Shows that human-caused methane emissions can be reduced by up to 45% this decade. Such reductions would avoid nearly 0.3°C of global warming by 2045. (Climate and Clean Air Coalition (CCAC) and the United Nations Environment Programme (UNEP), May 6, 2021)
18:58:31	Frank Landis	Great points Jack. Prorate.
18:58:37	Masada Disenhouse she/her	++ Jack Shu 😍😍
18:59:17	Brenda Garcia Millan	The RDF must prioritize good union jobs and a jobs pipeline for working-class people of color.
18:59:29	Maleeka Marsden	++Yeah Jack!
18:59:33	Ellee Igoe	Why aren't agricultural jobs ever included in green jobs? Seems like a huge oversight that I hope isn't left out of the workforce plan Supervisor Vargas was announcing.
18:59:39	Kori Ellis	Lynda Daniels, Desalination- can be double processed, the salt can be used in the new generation nuclear reactors that help process spent nuclear fuel. The newer generation nuclear reactors can give all of us zerocarbon energy while cleaning our air and getting off of fossil fuels.
19:00:02	Wendy M She/Her	Great points Craig!
19:00:03	hope nelson	How does air travel impact the issue?
19:00:28	Jose Torre-Bueno	Given the issues with methane a program to trace and fix pipeline leaks would be a good jobs program. Also electrification to reduce the extent of the distribution network
19:00:30	Debra Kramer	In agreement with Jack, we need to lower our footprint NOW
19:00:37	Karl Aldinger	please consider a rapid transition for our public transit to all electric. Specifically our trains must go electric andthey should be an anchor for our transportation. BRT will be challenging to sustainably electrify with batteries. We can and should focus on the lowest emissions most efficient solutions in electrifying transportation including ebikes which are an equitable mode much more accessible to more people. Bike infrastructure and mixed use buildings will allow people to massively lower VMT in ways electric cars will not.
19:00:37	Toshi Ishihara	We need to have large scale GHG sequestering projects funded by the governments that have emitted more GHGs than others. Of course, we need to improve natural sequestering, but it will not be enough to capturethe GHG already accumulated and will be released.

Time	Commenter	Comment
19:00:49	Masada Disenhouse she/her	Craig thank you for emphasizing climate justice
19:01:24	Rosa Alcaraz	Yes this has been going on for Decades! Great point Jack to start now and reduce ASAP
19:01:28	Brian Shuck	Car dealers will shut down as most old makers have decided not to seriously pursue EVs in time to keep up. We should allow no new ICE vehicle dealerships
19:01:29	Shelah Ott	Well said Gloria!
19:01:36	Kerry FORREST	I agree with the Ramona Planning Group, We in Descanso are in a similar situation, We have a population of lower income and ignored. Our communities are underserved in transportation accessibility, energy that is cut off, no broadband internet. We are viewed as the perfect site for these energy farms and composting sites. Thisgets these projects out of the city dwellers view, makes them happy and really impacts our country way of life and our biodome is greatly damaged.
19:01:37	Jose Torre-Bueno	Its not clear that any large sale sequestration other than natural sequestration will work at all.
19:02:10	Vanessa Forsythe	Is consideration being given to more frequent reporting of health impacts of climate change? Climate changeevents are causing more severe debilitating physical and mental health conditions? People on call aware of climate change impact but many others are not. Need people to be informed so they can understand intersection and we can determine efforts to mitigate the health impacts.
19:02:21	David Harris	Gloria Conejo- Great comments!
19:02:22	Masada Disenhouse she/her	++ Gloria for all of our nieces and nephews + equity + transparency + green union jobs. Escondido - 97 degrees today when I was there.
19:02:29	Marian Sedio (North County Climate Change Alliance)	Yes Gloria!
19:02:31	Katie Meyer	Yeah Gloria!!
19:02:40	Bea Alvarez - Carbon Sink Farms	The concerns about jobs/workforce must include farmworkers and the livelihood of farmers.
19:02:44	Bob Wilcox	Transportation is our largest sector of emissions, and even with fully electrified transit this will remain a dominant end use of energy. The most impactful thing we can do is to increase density in areas that are alreadydeveloped to prevent sprawl and reduce vehicle miles traveled. Build up, not out!
19:03:19	Jose Torre-Bueno	totally agree w/ Bob
19:03:45	Brian Shuck	I just want to point out that I see some fossil fuel disinformation talking points above regarding EVs and batteries. There are already recycling projects going on. This is not our problem. And lithium is not at all rare. The proper things are happening in this area.

Time	Commenter	Comment
19:04:29	Kerry FORREST	Bob, just don't make the backcounty a "district 13" which exists to serve the dense pack communities "district 1"
19:04:52	Nastassia Patin	Agree with Bob as well. Massively expanding public transit and link residences to jobs will be crucial. Decreasing car dependence will have enormous implications for carbon emissions.
19:04:56	Craig Jones	Hydrogen from fossil fuels is NOT the answer . . .
19:04:57	Jay Lukes, The Lukes Network	This is an issue that goes accross political lines and unions. There are those that sit accross the aisle that believe in sustainability.
19:04:59	Toshi Ishihara	Too many people are still looking the other way, and running AC all day long even in the night. We need to educate them. We can buy prime TV time at multiple TV stations, and tell them how bad the climate situation is and we are the ones who is damaging this planet to “point of no return”
19:05:04	Dianne Woelke	If climate change isn’t brought under control…no one, even union workers, will have jobs….you need to think further down the line …..7 generations
19:05:08	Masada Disenhouse she/her	Thank you Sean and your members for your work. Our goal is to work with you to ensure we can transition everyone to a healthy, sustainable future as we go to zero carbon. Green union jobs!
19:05:12	Kori Ellis	Nuclear energy protects air quality- zero emission clean energy. Nuclear energy's land footprint is small. Typically 1000 megawatt nuclear facility needs a little more than 1 sq mile to operate. Nuclear Energy Institutesays wind farms require 360 times more land area to produce the same amount of electricity and solar photovoltaic plans require 75 times more space. Nuclear energy is extremely dense. It is about 1 million times greater than that of other traditional energy sources. 1 one inch uranium pellet is equivalent to 17,000 cubic feet of natural gas, 120 gallons of oil, or 1 ton of coal.
19:05:14	Ann Feeney	Agree with the comments against using CCS. Far better to just stop using/burning fossil fuels in the first place, and not depend upon removing carbon from the atmosphere after we have put it up there.
19:05:38	Vanessa Forsythe	We are here with you supporting our workers!
19:05:57	Heather Hofshi	I agree that a robust strategy using many different kinds of green energy is absolutely the way to go— defensein depth, as they say. Sean, I would love to hear more about where you think the future of green jobs is going and how we can support that transition
19:05:59	Cathy Gere	Electrification provides lots of good pipefitting jobs!
19:06:26	Craig Jones	The poll disappeared
19:06:29	Adam Aron	Agree with Cathy. And we can still have plumbers!
19:06:50	Brian Shuck	Also note: we cannot rely only upon governments to force us to change our ways. Many can stop flying frivolously now, as I did 6 years ago. I stopped buying gasoline years ago also. EVs are getting cheaper.
19:06:56	Masada Disenhouse she/her	where's regulation?

Time	Commenter	Comment
19:06:57	Gloria Conejo She/Her	@Bea Alvarez, yes. we have a large population of farmworkers in N. Inland. they must included
19:07:06	Adam Aron	I don't see leaving fossil fuels in the ground as an option.
19:07:15	Terri Steele	Right on, Sean! It's an integrated approach that will ensure our success. Demystifying the broad reach of green collar jobs and the skills needed to fill them is critical. Let's make a concerted effort to leverage the oodles of state and federal monies available for community and economic development to provide both existing/impacted and *aspiring* professionals with training to equip them to swiftly fill the career opportunities across all sectors to support job creation, retrofitting residential and commercial buildings with energy upgrades and renewable energy improvements. Perhaps we can get some savvy grant writers and PACE(Property Assessed Clean Energy) contractors to accelerate upgrades with no up front cash in ways that will save energy, reduce energy costs for property owners, allow residents to live more comfortably and improve the energy integrity of the region's building stock. (The source of a large percentage of any municipality's emissions!)
19:07:22	Ellee Igoe	I have no boxesbtoncheck!
19:07:27	David Harris	How about transformation of our fossil fuel economy
19:07:32	Frank Landis	Poll answer: Impactful Deep Transformation is a bit nebulous ....I'm with Adam, that leaving GHGs in the ground is the most important.
19:07:38	Katie Meyer	I think its important that we include a just transition so that workers can be part of green union jobs. We must transition away from fossil fuels, but include workers in that. Lots of potential green jobs!
19:08:00	Gloria Conejo She/Her	@katie meyer
19:08:02	David Harris	How about transformation of inequality in our society
19:08:23	Susan Wayo	Policy Support: Align what the CPUC is doing/thinking!
19:08:24	John Eldon	Technology is number one by far. This is how we get increased efficiency, reduced pollution, new jobs and economic opportunities.
19:08:31	Sonja Robinson	Goal-based development should have specific metrics and a roadmap to achieve and analyze
19:08:34	Toshi Ishihara	Buy used EVs and give them to those who cannot afford buying EVs.
19:08:39	Craig Jones	Policy support means, changing STate and local laws to allow aggressive regional coordination
19:08:39	Wendy M She/Her	Regional Integration: The County must use the RDF process to ensure continuity in substantial initiatives acrossthe region. As an example, the move to electrify buildings (BE) - second only to transportation in GhG - will be vital to achieve our climate goals. The County could play a big role in this effort by coordinating with cities to provide access to financial and technical assistance, offer draft code language and generally promote similar practices across the region. BE will happen. A patchwork of different city regulations doesn't help developers, contractors, or homeowners. Let's include this type of support in the County plan!

Time	Commenter	Comment
19:08:43	Ellee Igoe	Other! Funding for pilot projects and bringing grassroots solutions to scale.
19:08:44	Bea Alvarez - Carbon Sink Farms	we need programs to support existing farmland to continue producing regeneratively or transition from conventional to regen ag, encourage new farms and support farmworkers rights and social programs that elevate their livelihoods.
19:08:48	Jose Torre-Bueno	We need to include workers but we should not allow the workers to be used as pawns of the companies that dont want to decarbonize
19:09:12	John Eldon	Yes to nuclear. Fusion in the future, fission for now.
19:09:19	Karl Aldinger	a Just Transition for affected workers is critical because we are divided on mo
19:09:25	Susan Wayo	We DON
19:09:27	Gloria Conejo She/Her	@jose torre-bueno
19:09:30	Peter Zahn	1. electricity is the linchpin of decarb – we need to reduce electricity to near zero or zero co2 emissions, and massively increase the supply (probably 2X). 2. adaptation is barely off the ground in the County – cities need enormous technical and financial assistance, not to mention unincorporated areas 3. extended producer responsibility – County could lead the way in requiring producers of products to take responsibility for the costsof managing their products (like plastics) at the end of life 4. single use plastics need to be restricted – to reduce fossil fuels and harmful waste 5. equity front and center – everyone must be allowed/invited/helped to join or we'll never reach the tipping point to contain global temperature rise
19:09:31	Ashley Jabro	nuclear energy is great. too much fear mongering about a safe and clean energy source
19:09:34	Katie Meyer	Policy changes and regional integration
19:09:38	Susan Wayo	We DON'T NEED NUCLEAR!!
19:09:42	Brian Shuck	We need to switch to EVs ASAP through bans of ICE, new gas stations, commiting car pool lanes to ZEVs. Electricity is already getting cleaner; we just can't let SDGE stop rooftop solar, etc.
19:09:44	Masada Disenhouse she/her	Sorry to be blunt, but I feel like this is doublespeak when we know we need to stop extracting and burning fossilfuels and transition our energy, transportation, housing and other sectors to renewable energy...
19:09:48	Karl Aldinger	many choices when workers jobs are on the line.
19:10:10	Adam Aron	It's not possible to scale up new nuclear in the time frame we have, it takes 9 to 19 times as long as building utility scale wind or solar and at a cost over 10 times as great, Mark Jacobson, Cambridge University Press 2020.
19:10:16	Rosa Alcaraz	ABSOLUTELY NO NUK!
19:10:18	Jay Lukes, The Lukes Network	Amen, John

Time	Commenter	Comment
19:10:19	Vanessa Forsythe	Policy support includes dates for enacting and funding. Peope center transition includes transparency informing and involving public and creating jobs.
19:10:20	Masada Disenhouse she/her	^^ Adam
19:10:26	Prasad Naga	Revisit economic theories of prosperity definition which relies on extracting/exploiting earth, mass producing and selling it at profit for GDP growth. Example selling more cars is good for Automotive sector and is good for the GDP of USA.
19:10:30	Jose Torre-Bueno	Given the time and cost to build nuclear plants it is not a viable alternative.
19:10:33	David Harris	John Bennett- we haven't forgotten Three Mile Island, Chernobyl, Fukushima…
19:10:36	Ann Feeney	We do not have any way to safely remove all of the spent fuel rods in San Onofre, nor any place to put it. Let's take nuclear off the list of options.
19:10:39	Andres Reyna	No new nuclear plants in earthquake zones.
19:10:44	Shelah Ott	Thank you for being here Yusef!
19:10:48	Toshi Ishihara	Dump nuclear waste in the backyards of nuclear industry executives.
19:10:53	Frank Landis	Nuclear needs cooling. Sea level rise makes it problematic near the coast, and our reservoirs fluctuate to wildly to be safe coolant pools. Also, it takes 10-20 years to bring a plant online, and that's too slow.
19:10:59	Preston Brown	I think you need rephrase this question the possible selections seem to indicate themes of things that would obstruct the progress of decarbonization not as things of themselves that would impact. These ideas need to beseparated. Thanks.
19:11:01	Craig Jones	It will take DECADES for nuclear generators to be online, in the meantime we need to really promote distributed rooftop solar . . . including agressive installation in disadvantaged communities
19:11:06	Masada Disenhouse she/her	Yusef Divest CALPERS & CalSTRS from fossil fuels
19:11:09	Heather Hofshi	+Yusef!
19:11:13	Katie Meyer	Yassss!!
19:11:20	Brenda Garcia Millan	great message Yusef!
19:11:21	Gloria Conejo She/Her	@Yusef miller
19:11:22	Jack Shu	Yay Yusef Miller
19:11:27	Debra Kramer	Yes Yusef
19:11:32	Kori Ellis	Regarding San Onofre Nuclear Generation Station: Reprocessing the nuclear spent fuel that we currently have can create thousands of jobs, create Hydrogen, zero carbon power to desalination.
19:11:33	Sonja Robinson	Yusef
19:11:36	Kerry FORREST	Dump solar and wind farms in downtown san diego and La Jolla

Time	Commenter	Comment
19:11:37	Courtney Ransom	Hi, I'm Courtney with the San Diego Democrats for Environmental Action and SD Green New Deal Alliance. I love the point on geopolitical cooperation and wanted to ask what you think this would look like as a strategyin San Diego. Is there an example issue where we could especially leverage geopolitical cooperation?
19:11:41	Vanessa Forsythe	Yes Yusef job training in new industries. Solidarity!
19:11:42	Jay Lukes, The Lukes Network	We all breathe the same air.
19:11:46	Katie Meyer	*snaps*
19:11:47	Adam Aron	Yay, nice Yusef!!! Let's work together Union, there are plenty of jobs in the transition. Leave fossil fuels out of it!
19:11:52	Marilyn Bruno	We have been working with DOE (Lawrence Berkeley National Lab, Sandia National Lab, etc.) for the past 3 years, demonstrating that the fastest, cheapest green biofuel production is from algae. Production can be donein backyards, rooftops, unused land, or mega algae farms - indoor and outdoor. These projects create new jobs (cultivation, biomass drying, shipping) and opportunities for downstream green co-products.
19:11:57	Wendy M She/Her	yes Yusef!!!!
19:12:02	Judi Schlebecker	Again the major source of GHG is from vehicles. An essential goal should be a great transportation system with low cost housing in transportation hubs. This should be #1 in Goal-based development.
19:12:25	John Eldon	algae -- yes!
19:12:26	Bill Tippets	Without Regional Integration this area will never get on track to get on decarbonization. That's currently the role that SANDAG is supposed to play (at least from the transportation system housing allocation frameworks).But SANDAG is really just the cities and county agencies, so those elected officials have to work together, not for parochial interests. They must commit to developing real (achievable, fundable, and timely/implementable) programs and projects. And that means they must put money/financing into the most effective and needed sectors (which embeds social/env. justice.............).
19:12:34	Brian Shuck	What disadvantaged communities need for the coming future: air conditioning, air filtration, and EVs
19:12:40	Kori Ellis	Sir, it is not nuclear waste, it is nuclear spent fuel. More than 90% of the potential energy still remains within each rod.
19:12:45	Masada Disenhouse she/her	Bill, must be regional
19:13:15	Cathy Gere	Public transportation!! So important!! The electric car cannot solve this thing
19:13:44	Adam Aron	That public transportation needs to be electric too Cathy

Time	Commenter	Comment
19:14:01	Preston Brown	I don't think Plumbers have to worry, Have a look at Plumber Engineers magazine. They will be direly needed in the movement of water and liquids in the future.
19:14:10	Jack Shu	Let's not forget to place reduction of travel and use of energy as what we can do. It is the most cost effective. Poor people are already doing it. It's the well to do, high and middle income people who are driving up GHGemissions and pollution.
19:14:11	Tim Snyder	Other: A campaign for acceptance of the reduction of most standards of living.
19:14:13	Kori Ellis	Frank Landis, nuclear energy especially the newer generations can be put online within 10 years right in line with all of this decarbonization timeline.
19:14:37	Masada Disenhouse she/her	++ Bee!
19:14:39	Ann Feeney	We must stop the burning of fossil fuels, methane gas, in our homes. There are excellent all-electric alternatives to gas furnaces, gas water heating and gas stoves. The County should mandate that all newconstruction and major renovations be all-electric. The County should also develop a plan to incentivize retrofits of existing buildings.
19:14:41	John Eldon	Need plug-and-play (120VAC, 20A) heat pump appliances to replace natural gas dryers and water heaters without expensive home rewiring.
19:14:42	Brenda Garcia Millan	Agree with Cathy: efficient public transit is key! it must be affordable and accesible to everyone.
19:14:44	Jose Torre-Bueno	the new gen reactors are still experimental we would not count on them
19:14:52	Sonja Robinson	Great comments Bee +++
19:15:01	Susan Wayo	Great comment about need to counter misinformation especially from fossil fuel based industries
19:15:20	Jack Shu	Ask the people in Japan what they think of nuclear power.
19:15:29	Tina Tran	As a youth, we need to stop extracting fossil fuel, but also not look to use nuclear energy. Nuclear waste is radioactive, we cannot dispose the waste in a safe manner. We see that currently in Japan.
19:15:41	Ashley Jabro	we need more public transportation and that transportation must be near where people live and work. less sprawl, more density
19:15:49	Annie A.	I'm a journeywoman plumber for local 230. Its important to use a balanced approach when decarbonizing our regions. Renewable natural gas will reduce green house gas emission, divert the landfill waste, and create high-paying Union jobs. Renewable natural gas projects capture the methane from existing food waste, animal manure, waste water sludge and garbage and redirect it away from the environment while repurposing it as clean green energy sources. I support the use of Renewable natural gas, hydrogen, long duration pump storage pump storage, CCUS, and nuclear energy as excellent options for this decarbonization framework.

Time	Commenter	Comment
19:16:10	Bea Alvarez - Carbon Sink Farms	Land Use (agriculture and conservation)
19:16:20	Craig Jones	Strategies as pathway to decarbonization: YES, transportation and land use! End land use sprawl, insist on coupling development intensification with WORKING public transportation.
19:16:23	Masada Disenhouse she/her	++ Nastassia transportation is the biggest component + we need a functional transit system!
19:16:31	Brian Shuck	We need to retrofit housing for getting gas out, including EV charging infrastructure, and solar installations. Local microgrids for resilience.
19:16:43	Kyle Heiskala, Environmental Health Coalition	a. we need to invest limited resources in zero-emission mass transit to reduce dependency on cars, and to electrify heavy-duty trucks - that charging infrastructure needs to be prioritized in environmental communitiesfirst
19:16:55	John Eldon	Public transit is no help without solving the "last mile" problem. The "first mile" problem is trivial to solve withpark-and-ride, bike-and-ride, etc., but if you can't get to your destination and back, public transit is useless.
19:16:57	Brenda Garcia Millan	transportation & land use: we need to stop sprawl development and build more affordable housing within existing communities. We won't achieve our goals if we keep forcing people to drive long distances to carry onessential activities like shopping, working or going to school.
19:17:06	Craig Jones	SANDAG's proposed "5 Big Moves" plan is a START to functional public transportation, we need more and faster
19:17:06	Vanessa Forsythe	Great point by Bee not just new buildings but also retrofitting new buildings. Note not everyone can afford anEV still and mining of rare elements for and disposable of batteries is an issue. EV not a ure all.
19:17:08	Mary Yang	We need to consider workers that will be affected but we should not fall for false solutions. August 2021 - NewReport showing why hydrogen is a false solution for replacing fossil fuels for heating & cooking in homes & buildings. https://earthjustice.org/features/green-hydrogen -renewable-zero-emission
19:17:22	Peter Zahn	Good point about reactors Jose. Regardless of their waste issues, which are terrible and unresolved, the technology is way to costly to go forward
19:17:25	Katie Meyer	Thats true Nastassia, transit is crucial
19:17:36	Ashley Jabro	would like to see the county raise awareness about the negative health effects of gas stoves and offer families free or affordable alternatives
19:17:42	Masada Disenhouse she/her	Mary
19:17:43	Brian Shuck	Autonomous EVs will solve the last mile personal transport problem fairly soon.

Time	Commenter	Comment
19:18:17	Terri Steele	Right on Yusef (and Nastassia)! San Diego's Barrio Logan has the third worst air quality in the state. I've been working with the community to initiate The Green Ride, an app-based electric vehicle shuttle system to address the environmental injustices that have plagued free-way and port-proximate communities for years by reducingvehicle trips, addressing parking congestion and air quality issues and ameliorate the challenges parking congestion imposes on local businesses. It can be easily replicated to create healthier, more walkable communities and then interconnect them across the region.
19:18:36	Peter Zahn	Good points about the need for outreach - on issues like building electrification, electric induction cooktops!
19:18:43	Yusef Miller Cleanearth4kids and NSDC-NAACP	Thar's right Terri
19:18:49	Valerie Lake	Some focus and investment should be on new tech to address reducing GHG in Existing vehicles and buildings. Solar and EVs are not the only solutions. Much of suburbia will never have convenient public transit or affordEVs and solar retrofits.
19:19:05	Adam Aron	Carbon capture and hydrogen and promoted by the fossil fuel industry to keep doing the same thing.
19:19:06	Danny	The City of SD and County of SD's multi-hauler trash collection services are ridiculous. Why are 10+ trash trucks going through streets and alleys to collect just 3 waste streams!? In addition to unneeded GHG emissions, trashtrucks are the heaviest on the road - tearing them up causing undue infrastructure investment from jurisdictions. It also lessens the quality of life for residents. Stand up to industry to make the changes necessary to achieve all of these climate goals. While some industries will undoubtedly suffer, others will absolutely flourish. Sustainable industries should be rewarded.
19:19:10	Craig Jones	Hydrogen is not green today; it's produced from fossil fuels
19:19:15	Courtney Ransom	Energy: Electrification! SDSU Mission Valley committed to building their Mission Valley campus to being nearly all electric and LEED Gold building standards on the site. This required a lot of pushing but could be possible forall developers.
19:19:23	Jack Shu	We can start addressing transportation by changing our funding system for road and freeway maintenance. Changing from fuel tax to road use fees will help reduce congestion and pollution. What we have now is notequitable.
19:19:32	Cathy Gere	Can someone from the unions please explain the link between diverse fuels and jobs?
19:19:50	Preston Brown	This question on strategies, it is splits in the purpose from the question to the possible answers. You ask aboutstrategies then you give us choices users of or producers carbon. These are 2 different ideas. For instance, ENMERGY is not a strategy.
19:19:59	Brian Shuck	Allow voting on comments here in the future

Time	Commenter	Comment
19:19:59	Ann Feeney	Agree with Mary that hydrogen and renewable natural gas are not good solutions. Stopping the burning of fossil fuels ASAP should be our approach. We are in a "Code Red for Humanity" crisis that demands immediateaction.
19:19:59	Mary Anne Viney	Why are GHGs from aircraft not included in our GHG county inventory? We have many airports located within 10 miles of low-income and disadvantaged communities. Communities have the right to know.
19:20:20	John Eldon	Replace sprawling business parks and commercial centers with mixed-use with affordable housing.
19:20:28	Jose Torre-Bueno	I dont think we should choose alternatives because they currently are employing workers. It needs to be theother way around. We need to figure out the optimal strategies and then retrain any workers who are displaced by any changeover.
19:20:37	Cathy Gere	There is not enough renewable natural gas to make a dent climate change
19:20:50	Ann Feeney	** agree with Jose
19:21:19	Toshi Ishihara	Make public transit free to all county residences. It does not cost much. Only 30% (?) of MTS revenue is coming from ticket sales. Then increase gasoline tax and implement road use fees.
19:21:19	Jack Shu	We can also take away the idea that "free parking" exist. all parking should have a price.
19:21:22	Margaret "Peggy" Budd	What makes sense to me is to eliminate more carbon in the air by cutting it at the source; i.e. stop fossil fuel corporations from drilling and fracking, and putting the oil in pipelines. This stoppage can be "encouraged" by divesting from these corporations, the banks, and insurers that fund their projects. I suggest that San Diego County do that divestment in the County's Pension plan. Supervisor Vargas as a member of the SDCERA Board could look into that as part of the decarbonization plan.
19:21:26	Kerry FORREST	If you have ever been in a commercial kitchen all the ranges and ovens are gas for good heat control with cooking. if you go to all electric you can kiss your fine dining restaurant experiences good by
19:21:42	Vanessa Forsythe	have smaller generation sites that are eltrical and available to communities
19:21:49	Vanessa Forsythe	yes local hire
19:21:51	Wendy M She/Her	A plumber installed my electric heat pump water heater. a low-emission climate friendly alternative to gas
19:21:54	Courtney Ransom	Energy: Energy efficiency and solar incentive programs, especially on bill financing and for multi-family housing
19:22:01	Jose Torre-Bueno	actually that is not true at all induction ranges work fine and there will be a presentation about that in SD
19:22:09	Bee Mittermiller	The water infrastructure in the County is in desperate need of work. = alternate work for gas workers?
19:22:13	Cathy Gere	Thanks for this input. Cristina! We need to make transition jobs into good union jobs!!
19:22:15	Ann Feeney	Induction cooktops have precision control of temperature of cooking. You do not need gas stoves for that

Time	Commenter	Comment
19:22:29	Brian Shuck	A carbon tax would go a long way towards the goals; reduce ICE use and air travel until planes become clean
19:22:31	Bee Mittermiller	True Ann!
19:22:36	Craig Jones	San Diego region has incredible potential to become a world leading clean energy and storage leader, this can create incredible work opportunities
19:22:41	Brenda Garcia Millan	a. Transportation & Land Use: we need to build more missing-middle housing projects (ADUs, cottage courts, fourplexes, etc). We can look at examples from other West Coast cities like Portland, Oregon.
19:22:56	Nancy Petitti	Improved public transportation systems must be paired with a large push to increase the number of low/noemission vehicles. And a marketing campaign to convince people that they can ditch their cars for public transport without experiencing a major loss of accessibility.
19:23:20	Ellee Igoe	What kind of incentives can be advocated for in this Plan to help industry transition to solar, electrical and other climate smart practices? What types of shovel ready projects can we include in the Plan to be ready when Federal infrastructure $$$ start to flow?
19:23:48	Jim Peugh	I hope that we will seriously look into how to optimize nature-based carbon sequestration. It has some attractive by-products. It would discourage sprawl and encourage saving habitat for native species. It would probably be relatively low cost. We would probably need to improve our fire fighting capabilities, but we are going to have to do that anyway.
19:23:50	Brian Shuck	Let's be real on mass transit. We can't fill the trains with surfboards, etc. We have to get ICE off the roads
19:23:52	Shelah Ott	Ellee
19:24:03	Clemencia Pinilla	I think Vanessa brings a very important point! Thank you Vanessa!
19:24:06	Bee Mittermiller	Kerry, a good cook does just as well with all electric
19:24:26	Dianne Woelke	Hi, Vanessa. I’m a retired Advanced practice and public health nurse. Please provide link to your organization
19:24:35	Anne Sheridan	We should be counting all emissions that result from activity that takes place in the county. For example, this would include conducting a life-cycle analysis of products and materials that the county - or even the public atlarge - purchases even if the emissions occur outside of the county. It doesn't matter where the emissions occur if our activity is causing it.
19:24:54	Masada Disenhouse she/her	strategies: All of the above

Time	Commenter	Comment
19:25:05	Heather Hofshi	Fine dining won't survive the effects of climate change except for the super wealthy if we don't act. Good chefscan learn to cook on new stovetops, but restaurants will struggle in a future marked by frequent disasters and economic instability. Doubt people in New Orleans are super concerned about fine dining this week.
19:25:20	Kori Ellis	Technologies that should be considered on path to decarbonization while creating good union jobs during our transition- Renewable natural gas, Hydrogen, Carbon Capture Utilization & Sequestration, Geothermal & LongDuration Pump Storage, Water batteries, Hydroelectricity, & Heavy Duty Transportation Technologies
19:25:33	Vanessa Forsythe	https://www.climatehealthnow.org/mission health care providers come join us
19:25:34	Rosa Alcaraz	We need to work on our mass trans system by making it affordable so more folks can use the trolley, rail service
19:26:05	Brian Shuck	As was said, setting higher gasoline taxes will help
19:26:36	Jack Shu	Let's make sure Project Labor Agreements or Community Benefit agreements are part of the plan. This will protect workers, keep quality apprenticeship programs and support local labor.
19:26:41	Laura Hunter	A focus on EJ communities and those that constitute the 'heat-islands' and often the food deserts in our communities should be a focus. There could be a very focused effort to address the vulnerability in these neighborhoods. It could include building retrofit program (job creator), increases in the urban forest, covering rooftops/parking lots/roads with solar panels (job creator). I would also recommend the County help us get ridof the energy 'wheeling' prohibition so that neighborhoods could actually create and share energy created and even perhaps an economic benefit to those residents. We need to deploy rain water capture and rain water capture (jobs) which could also support community and individual gardens through out our urban areas so they can become more resilient, food secure.
19:26:44	Ann Feeney	Heat pump water and space heaters, induction cooktops. These are mature technologies, and are in widespread use elsewhere in the US and overseas. No reason to use methane gas-burning appliances in thehome. In addition, gas stoves produce high levels of indoor air pollution, resulting in severe health risks, especially asthma and other respiratory diseases.
19:26:45	Masada Disenhouse she/her	katie we need to stop sprawl and engage with union members
19:26:58	John Eldon	Revenue-neutral carbon tax-and-rebate.
19:27:05	Brian Shuck	Paint roofs white; no-brainer.

Time	Commenter	Comment
19:27:10	Robert Lewallen	Rob Lewallen, Chair of the Ramona Design Review Board here…… This is a comment about the CA PUC. It seemsto me that folks generating power with their rooftop photovoltaic systems need to be reimbursed for excess power that they put back into the grid - through the utility companies - at a more equitable rate than the meager, exisitng, lower-than-wholesale amounts. If we could get that up to closer to what we are charged for power, many folks would then install oversized systems…… creating a whole lot of individual electrical power suppliers with no costs other than that to the individual home system owners . The infrastructure system is already in place via the existing distribution systems already in place. This would eliminate much of the need fornew transmission lines and help to reduce the use of dirty electrical generation. Thanks for "listening".
19:27:31	Cristina Marquez	Thank you Cathy Gere!
19:28:03	Kerry FORREST	I agree Rob
19:28:07	Shelah Ott	Go Sonja!
19:28:08	Debra Kramer	I agree Sonja
19:28:13	Craig Jones	Google energy storage ideas: many of these will work well, e.g. industrial size new-generation flywheels, and non-flammable next-gen lithium and other batteries. Again, where there is a will, there is the way
19:28:23	Yusef Miller Cleanearth4kids and NSDC-NAACP	Yes Sonja!!
19:28:24	Brenda Garcia Millan	well said Sonja!
19:28:27	Laura Hunter	Last, it would be great if this plan could propose consistent sample policies for cities. For example, Escondido just voted down its Planning Commission's proposal for an Urban Greening Plan. This was a huge loss for our residents. This decarbonization plan could really offer policies and clear directions on the kinds of actions andpolicies that are needed in the region. If the County helped fund those actions...that would also help too!
19:29:00	Nancy Petitti	Agreed, Sonja!
19:29:05	Bill Tippets	Top priorities for decarbonization: reformed transportation infrastructure/system; new housing/developmentin Smart Growth areas; all new building must be zero net energy by 2030 and any sale/redevelopment project must be net zero. Finally, micro and smaller photovoltaic and wind (where feasible) facilities should be put on (financed by public funds to a reasonable degree) all buildings. Do Not defer to megascale,PV on out lands (wind facilities are much more topographic limited, but even these should not be placed in highly sensitive or rare habitat areas).
19:29:11	Craig Jones	laura
19:29:42	Brenda Garcia Millan	laura Hunter

Time	Commenter	Comment
19:30:02	John Bottorff	New nuclear power costs about 5 times more than onshore wind power per kWh. Nuclear takes 5 to 17 yearslonger between planning and operation and produces on average 23 times the emissions per unit electricity generated. In addition, it creates risk and cost associated with weapons proliferation, meltdown, mining lung cancer, and waste risks. Clean, renewables avoid all such risks. Mark Z Jacobson, Professor of Civil and Environmental Engineering & Director, Atmosphere/Energy Program, Stanford University
19:30:15	Kerry FORREST	roof top solar with batteries using existing distribution systems is the way to go. The sunrise power link hasdestroyed our viewscape and we still have power alerts and shutoffs
19:30:20	Terri Steele	Cristina - there is a pilot project in San Diego County that provides monies for lower income families to get into the EV market...then there are options for EV-PV (Electric Vehicles Powered by Photovoltaics). San Diego needsto be poised to immediately harness infrastructure monies coming out of Washington for EV modernization. The training of your workers in EV infrastructure and maintenance is terrific! If the County could be a repository for the full gamut of state, local and federal incentives available to help each citizen, business owner,laborer with assistance (incentives that inspire them to identify and act on where they fit into achieving our regional decarbonization strategy) we can really have an impact (and overcome prospective political obstacles to boot!)
19:30:23	Jack Shu	One measure of equity is when a person who lives in Logan Heights and travel (on public transit) 5 miles in the same time that someone who lives in La Jolla drives 5 miles.
19:30:36	Masada Disenhouse she/her	Sonja to metrics and a taskforce to ensure equity
19:30:40	Craig Jones	AGain: subsidize installation of photovoltaic solar in underserved communities, on apartment buildings, etc.; for more equity
19:30:48	Katie Meyer	Sonja
19:30:53	Aleksandra Ristova-Sanyal	Well said, Sonja!
19:30:57	Brian Shuck	We need more public education, starting in schools if we need by-in. Because people are resisting what needs to be done already
19:31:07	Heather Hofshi	+Sonja!
19:31:16	Laura Hunter	I agree with Sonja about the creation of a panel or advisory group to oversee the development of the plan. It might be a good model that when CARB was developing the AB32 plan, there was a statewide EnvironmentalJustice Advisory Group. It might be a good model.

Time	Commenter	Comment
19:31:32	Kyle Heiskala, Environmental Health Coalition	offer compensation to people living in environmental justices communities for sharing their lived experience
19:31:34	John Bottorff	Carbon capture is expensive, unproven technology. It is unnecessary. Existing clean energy solutions already exist
19:31:45	Nancy Petitti	Retrofitting (Greening) existing buildins can be a low-cost solution that would provide jobs for the construction industry as well.
19:31:57	Courtney Ransom	We are freaked out!
19:32:02	Margaret "Peggy" Budd	San Diego County divest from fossil fuel corporations the banks and insurers that back their projects. Supervisor Vargas is on the pension board. that can happen now and stop more carbon in the air.
19:32:14	Shelah Ott	Yes Adam!
19:32:15	Masada Disenhouse she/her	1) call it something more accessible than RDF 2) community workshops 3) conversations at schools, businesses,churches, etc. 4) show people how climate impacts them and invite them to be part of the solution
19:32:34	Jose Torre-Bueno	Divest is a good start !
19:32:34	Masada Disenhouse she/her	++ Peggy Divest from fossil fuels now!
19:32:36	John Bottorff	Ideas for the future….offshore wind to create not just clean energy, but green hydrogen which can be used to store energy, power ships, trains, etc
19:32:38	Dianne Woelke	Addiction to fossil fuels and plastics is what has happened. Turn Off the Tap!
19:32:55	Wendy M She/Her	CLIMATE EMERGENCY
19:33:05	Masada Disenhouse she/her	Adam - specific, enforceable plan that keep fossil fuels in the ground
19:33:07	Maleeka Marsden	A few questions/recommendations: This plan was originally called a "zero carbon" plan, and the goal was to commit to zero carbon (getting off fossil fuels entirely) by 2035. I want to confirm that is still the plan? Also, along with the jobs/workforce analysis, will it also be coupled with policies to keep workers whole and ensure a just transition? Regarding centering justice and equity—will the county do outreach to working class communities of color to create policies to make sure that benefits and investments are prioritized in these communities? Lastly, this plan should be specific and actionable (we need this to be more than a high level document), and progress should also be tracked. Additionally, measures included should be coupled with a cost analysis, and ideally identify funding sources as well.

Time	Commenter	Comment
19:33:29	Craig Jones	Engaging the community: yes, to Sonja's idea of an advisory committee for equity. And also for engagment:KEEP saying, publicizing, the need and the potential solutions, positive ideas, OVER and OVER again
19:33:30	Shelah Ott	Engaging the community - working with community leaders in communities of concern and providing compensation for participation for those folks. ++ Sonja’s recommendation to create an environmental justiceadvisory board
19:33:45	Brian Shuck	On the topic of plastics and the microplastic pollution, encourage the purchase of more sustainable clothing; see Patagonia and Prana brands.
19:34:00	LYNDA DANIELS Sierra Club	we can cooperate if there is a will to do so!
19:34:03	Ann Feeney	Adam. Agree with all you are saying.
19:34:12	Masada Disenhouse she/her	same for the high school students we work with
19:34:17	Maleeka Marsden	+++
19:34:19	Sonja Robinson	Thank you for your comments Adam +++
19:34:26	Tina Tran	Adam
19:34:26	Jack Shu	Equity is also when the air quality from one part of county to another is good enough for a child to safely play outside.
19:34:32	Craig Jones	To end plastics pollution, laws must simply outlaw their use - esp. use-once plastics
19:34:42	Vanessa Forsythe	Agreed we need to communicate hope and action! Yes many young people are resigned to climate change ending our world.
19:34:44	Sonja Robinson	Absolutely Jack...thx for saying that
19:34:46	Kyle Heiskala, Environmental Health Coalition	Carbon capture, utilization and sequestration (CCUS) is a false solution to climate change and dangerousdistraction. We need direct emission reductions, using proven zero-emission technologies
19:34:50	Laura Hunter	It would be great if the County would fund a Climate Commission and climate organizers in every city or at leastin every region of the County so that there could be direct communication to city leaders from the most impacted communities. We need to develop a formal channel of communication and we don't have it now. It would be great to have the County hire youth organizers to do outreach deep into the communities.
19:35:05	Tim Snyder	Participation: Be honest with the communities about the changes coming to their standards of living;transportation, power usage, real property, recreation, independence and more.

Time	Commenter	Comment
19:35:06	John Bottorff	"Natural" gas is methane. We need to stop allowing it in new construction in the county. No exceptions. There are electric alternatives for everything already available. Combined with rooftop solar makes it all very efficient
19:35:18	Jose Torre-Bueno	The key is going to be engaging workers without making the solution keeping the existing jobs in tasks that need to change. The unions need to recognize that their interests are not identical to the companies.
19:35:33	Shelah Ott	Yes Bea!
19:35:51	Sydney Pitcher	Clean transportation, storm water capture and rain harvesting, pandemic preparation and prevention, green hydrogen, fire prevention, forest restoration and protection
19:36:14	Kori Ellis	John, methane occurs naturally- through food, through waste, through fertilizer, through animals, and through humans.
19:36:25	Brenda Garcia Millan	I think it's important to work with students. We could use service-learning programs and partnerships with universities and k-12 schools.
19:36:25	Vanessa Forsythe	Agree with Maleeka action that is measureable.
19:36:27	Clemencia Pinilla	Thank you Adam! We definitely need think long term! Anything that we can do to make the world just a little better.
19:36:34	Debra Kramer	Yes Bea
19:36:36	Brian Shuck	We also need more air quality sensors. The EPA and therefore SDAPCD has failed us here. We will not be able to measure those equity improvements.
19:36:51	Cathy Gere	Renewable natural gas, 'blue' hydrogen, and carbon capture should not be included in the RDF: these are industry strategies for keeping the carbon bubble inflated
19:37:10	John Bottorff	Yes, Kori. It does. But SDGE is not piping that into homes and businesses. They drive the fracking industry which is incredibly destructive
19:37:16	Adam Aron	Agree with Cathy
19:37:23	Shelah Ott	Ellee
19:38:03	Ann Feeney	Agree with Cathy - keep RNG, CCS, hydrogen out of the RDF
19:38:06	Brian Shuck	Yes, on food, we can buy more at local low-carbon farms.
19:38:07	Shelah Ott	Recommended read is "Global Food Futures: Feeding the World in 2050"
19:38:08	Sonja Robinson	Thx for sharing Elle
19:38:12	Sydney Pitcher	Those are some ways we can fight climate change and do not forget we need to phase out bee killing pesticides.
19:38:36	LYNDA DANIELS Sierra Club	Agree! Both needed!

Time	Commenter	Comment
19:38:44	Toshi Ishihara	It takes so much energy to make microchips for iPhone, EV, and others. I heard that Taiwan is building power plants to support TSMC and other companies to increase capacities. We need to make people aware of all those costs and impacts on our environment. Lots of energy and materials are used to build cars including EVs.We need to reduce our energy and material consumptions. Unless people change their behaviors, everyone will lose (very soon).
19:38:49	Adam Aron	We need a plan of Towards Carbon Zero, bold, enforceable, now, and NOT “net zero” or “carbon neutral”: those are excuses to do nothing now, and to rely on technological rescue in the future.
19:38:56	Suzanne Hume CleanEarth4Kids.org	Go Sonja! So many great ideas in the chat! Awesome Community! Thank you, Jack Shu! And, Way to Go Yusef #Divest from fossil fuels! Let's make it happen! #Divest SDCERA, Cal PERS, Cal STRS... And, way to go youth, interns, volunteers! Sydney Pitcher, great work on #Divestment, clean air, water, stopping pesticides! Healthy soils are vital for a climate action plan! We have the pesticide data from what is being used on County of SD Lands. https://cleanearth4kids.org/stop-pesticides. We need a strong County IPM! We would love to collaborate! Yes! We need a bold plan. A link to our CleanEarth4Kids.org Action Plan is on CleanEarth4Kids.org. https://cleanearth4kids.org/clean-earth-4-kids-cap
19:39:02	Masada Disenhouse she/her	including aviation
19:39:21	Mary Yang	For engagement - SD Region should have a weekly TV or radio show that engages residents, workers, policy makers, businesses -- . Need platform for discussion and education. e.g. can interview homemakers/chefs re.induction cooktops, get input from labor, contractors, input from scientists, farmers, CCAs .... Share solutions on what we can do together and individually.
19:39:33	Karl Aldinger	Ellee's point about food supply risk is a huge concern. Our number one crop in San Diego is non-native landscape plants which is a bad priority.
19:39:34	Cathy Gere	the difference between carbon neutral and zero carbon is huge! I hope the RDF really hews to the latter
19:39:42	Bea Alvarez - Carbon Sink Farms	@sydney pitcher indeed, eliminate the use of pesticides and chemical fertilizers
19:39:56	Danny	we really need to be carbon negative at this point. that is why carbon capture and sequestration is so important. use nature - plant trees, apply compost and mulch. even consider planting kelp forests and restoringwetlands
19:40:09	Danny	subsidize regenerative farming

Time	Commenter	Comment
19:40:12	Nancy Petitti	The fear for the future that so many people are expressing doesn't seem to have swayed a large percentage ofour population. The fear of losing their way of living (driving, suburban communities) seems to outweigh the need for change to them. One way to convince people would be to start successful model projects that don't require big lifestyle changes for individuals to show the potential benefits of scaling up.
19:40:12	Masada Disenhouse she/her	Scott - building electrification now
19:40:18	Bee Mittermiller	Thank you, Scott!!
19:40:28	Kori Ellis	Danny- Totally agree!!
19:40:50	Cathy Gere	I agree with Karl Aldinger that natural carbon capture should be talked about separately from technical CCS
19:40:57	Brian Shuck	We should limit hydrogen delivery, even when we get green hydrogen, as who will have H2 pipes in theirneighborhoods?
19:41:04	Shelah Ott	Prioritizing communities of concern in electrification is key so they're not left behind or further burdened by costs they can't afford. Funding and creative solutions are needed
19:41:06	Adam Aron	Agree with Karl and Cathy.
19:41:10	David Pearl	Well said, Bea - agree 100%! Sequestration benefits of carbon farming are highly applicable in San Diego County and represent a win-win solution. As you said, incentivization and pilot projects are the path forward. SanDiego350's Food and Soil Committee strongly supports this.
19:41:12	Courtney Ransom	Scott, so cool to hear!
19:42:03	Heather Hofshi	Scott! Better to act now than have to fix our avoidable mistakes later. Penny wise and pound foolish
19:42:06	Brian Shuck	Yes; per the caller. No more gas allowed in new construction is another no-brainer.
19:42:13	Karl Aldinger	Building Electrification is definitely a critical move. Solar plus electric appliances are the most efficient and cheapest, most cost equitable route. Gas prices will rise as it is phased out which places heightened burden onthe last people who are left using gas.
19:42:30	Toshi Ishihara	County staff members, Thanks for arranging and supporting this event.
19:42:39	Adam Aron	Agree on building electrification, let's do it!
19:42:42	Sonja Robinson	Thank you County Staff
19:42:43	Cathy Gere	The new UCSD Hillcrest Hospital is projected to be 96% electric
19:42:46	Ellee Igoe	you are doing a great job facilitating!
19:43:02	Nancy Petitti	Can we get a copy of this chat stream?
19:43:20	Kori Ellis	You're doing a great job!

Time	Commenter	Comment
19:43:31	Masada Disenhouse she/her	click the 3 dots and say "save chat"
19:44:15	Nancy Petitti	Thank you, Masada!
19:44:28	Sydney Pitcher	Also, we should start building buffer zones that will reduce coastal flooding in the wake of rising seas.
19:44:34	LYNDA DANIELS Sierra Club	cruise ships pollute our oceans!
19:44:35	Scott Shell	I'd also like to recommend consideration of embodied carbon in new construction. There have been huge progress in the last few years to reduce embodied carbon in a cost effective and replicable manner. San Diego region already uses limestone/Portland cement and could be a leader in this regard.
19:44:36	Frank Landis	I'd love to see architects design homes whose roofs can hold enough solar to charge a car once per week (4 miles driven per kWh). How about garages where there's space next to the main circuit breaker box for a house battery? How about garages under apartments that are above the local water table, so that we don't have huge amperages meeting dirty water?
19:44:52	Craig Jones	Robin: the most cherished values of our rural communities will be best served, by keeping them rural - stop urban/suburban sprawl
19:45:01	Brian Shuck	For Robin and horse trailers, etc. Within 2 years, electric pickups will be out and better than the old ones
19:45:04	Jack Shu	No reason why all new homes and buildings should be net carbon zero with no off sets.
19:45:59	Masada Disenhouse she/her	Jim to public outreach and communication
19:46:02	Ashley Jabro	well said jim
19:46:05	Adam Aron	Good point Jim
19:46:07	Kerry FORREST	To engage with the community you need to talk with the planning groups who hold community meetings once a month in the community with the community
19:46:09	Nancy Petitti	Thank you, Jim!! Communications are key!
19:46:13	Brian Shuck	Per Jim's call: we need very much public education to undo decades of disinformation
19:46:16	Jack Shu	Great point Jim
19:46:48	Suzanne Hume CleanEarth4Kids.org	Yes! Building electrification! Stop natural gas in new construction! Why should people be exposed to air pollution when they are cooking dinner? Great job to Jim Wang for ALL of his important work and video withLeana and youth! Go SD Building Electrification Committee! Go Encinitas staff and city council for SO many reasons!
19:47:21	LYNDA DANIELS Sierra Club	Stop calling it natural gas - call it methane + pollutants!

Time	Commenter	Comment
19:47:34	Courtney Ransom	On engaging the community: granicus is awesome—get people on granicus, get young people on with creative content on new channels of social media (Instagram, TikTok?), give people food/things/money/appreciationwhen they participate
19:47:44	Yusef Miller Cleanearth4kids and NSDC-NAACP	AMEN RICK!!!!
19:47:54	Adam Aron	Just transition for the union workers … great points Rick
19:48:02	Susan Wayo	Agreed! Not "natural gas" because it isn't! It is methane +!
19:48:11	Brian Shuck	For the many jobs will be be going away, we need much retraining. But more importantly, as we go to more robot and AI work, a Univeral Basic Income would be needed.
19:48:16	Jose Torre-Bueno	Rick is spot on.
19:48:38	Yusef Miller Cleanearth4kids and NSDC-NAACP	Let's lay it out clearly for our Labor Brothers and Sisters!!!
19:48:41	Vanessa Forsythe	Yes aviation and GHG big issue and we should be looking to impact at county level and our airports. Yes stop calling it "natural gas". It is a lot about the way we are told things are and mis communicated
19:48:52	Jack Shu	Rick makes wise comments.
19:48:57	Masada Disenhouse she/her	++ Rick!
19:49:00	Katie Meyer	Agree with Rick\
19:49:01	Tessa Pierce Ward (she/her)	Methane was mentioned earlier in the chat, but wanted to bring it up again. Methane warms the planet 86 times as much as carbon dioxide over a 20-year period. Reducing methane emissions can provide some immediate benefits as we work on longer-term decarbonization. Reduction strategies include fixing gas pipelineleakages (or ideally reducing gas transport and utilization as much as possible), driving improved agricultural practices, and ensuring improved waste treatment and diversion, including food recovery and composting.
19:49:08	Marilyn Bruno	Register for DOE webinar on 09/15 - Local Energy Action: Building an Equitable and Sustainable Future withCommunities - https://www.zoomgov.com/webinar/register/WN_qRp07KZvQ3OBvSxjadXkxw
19:49:10	Clemencia Pinilla	I think the fact that we are having this discussion is a good start to hear all the voices. I do not think that today we are being presented a plan. I find fascinating that the voice of the youth is much more concern and moreopen to new ideas! We must be open to new possibilities.
19:49:29	Murtaza Baxamusa	https://www.sandiegocounty.gov/content/sdc/sustainability/regional-decarbonization.html

Time	Commenter	Comment
19:50:06	Scott Shell	San Francisco is doing interesting work on a plan to decarbonize large commercial buildings over a decade. Requiring a Strategic Decarbonization Assessment and timeline aligned with existing building leases and renovations. https://sfenvironment.org/energy/strategic-decarbonization-assessment#:~:text=A%20long%20term%20financial%20planning,and%20electrification%20in%20San%20Francisco&text=The%20Strategic%20Decarbonization%20Assessment%20(SDA,owners%20be%20more%20carbon%20aware.
19:50:10	Rosa Alcaraz	I think you should contact schools, the CBO's in the community to help spread Decarbonization because I don't think that most folks understand decarbonization!
19:50:10	Rebeca Appel | Countyof San Diego	Link to some reports mentioned in Elena Crete presentation: IPCC 6th Assessment Report (2021): https://www.ipcc.ch/report/ar6/wg1/ - Zero Carbon Action Plan, Sustainable Development Solutions Network: https://www.unsdsn.org/Zero-Carbon-Action-Plan
19:50:36	Brian Shuck	I just want to point out that the time for the actions that we are discussing was 10 or more years ago. We are now in an emergency caused by emissions from decades ago, as i understand.
19:51:04	Suzanne Hume CleanEarth4Kids.org	Rebates... for gas powered Leaf blowers, lawn blowers, farm equipment. Let's protect workers and public from toxic pollution and greenhouse gases. SEQUEL is a group meeting every other Wednesday at 3 pm. Please joinus!
19:52:09	Ellee Igoe	Come take a tour of our work on carbon sequestration and climate smart ag............... solidarityfarmsd.com/tours
19:52:10	Brian Shuck	For employers: educate them to not require that peoplle drive in every day for no reason, for those who canwork from home.
19:52:15	Tim Snyder	Best Strategy: Be honest about the effect of programs to control "climate change" on the county residents.
19:52:18	Marilyn Bruno	Aequor is in several projects with DOE. We can provide info on the many federal loans, credits, incentives forgreen products. mbruno@aequorinc.com
19:52:28	Vanessa Forsythe	Murtaza please keep public part of Regional Collaboration communications.
19:52:53	Cristina Marquez	Berkeley Report - https://www.documentcloud.org/documents/7197687-UC-Berkeley-report

Time	Commenter	Comment
19:53:06	Masada Disenhouse she/her	Hello - Masada Disenhouse with SanDiego350. Live in D2. Glad this process is underway - thank you. The biggest pieces for me are 1) This must be a regional effort, with a county-wide effort to build transit, affordable housing, and a green economy. 2) It must be bold, and it must start now. We must stop kicking the can down the road. There's no mystery about what we need to do - stop sprawl development, create a functional transit system, go 100% renewable energy for all home + business needs, etc. 3) The RDF must be specific and actionable - it can't be another unenforceable aspirational target, but an actual plan. 4) It must invest in makinga healthy, sustainable future for everyone - end the disparity in air quality, access to transit and housing. And it must ensure that impacted workers are fully supported and protected during the transition. Question: What is the plan for working regionally - coming up with an accountable plan that actually gets done, across the county and 18 cities? Thank you!
19:53:28	Scott Shell	Some pilot projects to retrofit existing homes would be very helpful. Menlo Park is doing some interestingwork in this regard, while avoiding expensive electric panel upgrades: https://www.youtube.com/watch?v=kojIFDKDtZU
19:53:30	Andres Reyna	Local non-profit is working hard to increase our urban forest, https://www.treesandiego.org/
19:53:41	Rick Bates	Masada
19:53:44	Masada Disenhouse she/her	Thank you for your work Murtaza
19:54:05	Sonja Robinson	Murtaza...ECJ
19:54:07	Rick Bates	Thank you Murtaza and staff!
19:54:10	Andy Pendoley | MIG (Meeting Moderator)	https://www.sandiegocounty.gov/content/sdc/sustainability/regional-decarbonization.html
19:54:20	Courtney Ransom	Thank you staff for your work on this. It means a lot to have the county taking action, and it feels meaningful that we get to participate.
19:54:42	Shelah Ott	The regional decarbonization framework needs to be as specific and implementable as possible so that there is a concrete pathway to actually achieve Zero Carbon by 2035. I know many of us are afraid this will end up beinganother document that is focused on goals and values rather than the action steps that are needed. The RDF should also include a range of provisions to secure workers' rights and livelihoods as the regional economy shifts to a Zero Carbon economy, and prioritize good union jobs along with a jobs pipeline from Communities of Concern for working-class people of color. We need metrics and concrete action steps that reflect the crisis we're in.
19:54:57	David Harris	Thank you Rebeca and Murtaza
19:54:58	Courtney Ransom	True Shelah!
19:55:11	Heather Hofshi	Masada 'Let's' have vision and be bold, instead of stumbling one step at a time and getting there too late

Time	Commenter	Comment
19:55:21	Brian Shuck	Thanks all
19:55:23	Rosa Alcaraz	Thank you as well
19:55:25	Dianne Woelke	Agree with stopping urban sprawl into the WUI….people are having home owners insurance non-renewals in the thousands in this county….their know. Municipalities need to listen!
19:55:25	Shelah Ott	Heather
19:55:26	Philip Gibbons	Thank you
19:55:27	Vanessa Forsythe	Thank you staff it was worth attending.
19:55:28	David Flors	On behalf of Vice Chair, Supervisor Vargas, thank you everyone for all of your input, ideas, discussion. This hasbeen a very rich conversation!! Appreciate all of your time and engagement! Thank you County staff!
19:55:28	Sonja Robinson	Thank you...
19:55:28	Tina Tran	Thank you
19:55:29	Jack Shu	Nice workshop, lots of public comments.
19:55:29	Sean-Keoni Ellis	Thank You all!
19:55:30	Suzanne Hume CleanEarth4Kids.org	Reduce plastics! Plastics emit methane (Dr. Sarah Jeanne Royer's discovery.) We must continue to pass SingleUse plastic ordinances and work for natural grass- not synthetic turf! Great job youth for your videos!
19:55:30	Robert Lewallen	Andy - good moderating….
19:55:33	Clemencia Pinilla	thank you!
19:55:33	Shelah Ott	Thank you all!
19:55:34	Katie Meyer	Thank you!
19:55:34	Heather Hofshi	Thank you!
19:55:34	Cristina Marquez	We thank you!
19:55:38	Frank Landis	Thank you!
19:55:49	Mike Bullock	I got a postcard about the widening of I-5. The BOS should object!
19:55:51	Susan Wayo	Great program! Thanks
19:56:40	Terri Steele	Wonderful work, team! The energy exhibited here tonight is inspiring! so excited for what's to come...