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ENERGY COMMISSION



ENERGY RESEARCH AND DEVELOPMENT DIVISION

FINAL PROJECT REPORT

**Mindful Gas Decommissioning:
A Data-Driven Tool for Equitable
Exploration of Gas Distribution
Pipeline Decommissioning in
California**

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To everyone who contributed their time, expertise, and perspective—thank you for helping advance equitable, strategic, and impactful gas decommissioning across California.

PREFACE

Established by the California Public Utilities Commission in 2004, pursuant to Assembly Bill 1002 (Wright, Chapter 932, Statutes of 2000), the Gas Research and Development Program is funded by California utility customers under the auspices of the California Public Utilities Commission. In 2004, the California Public Utilities Commission issued Decision 04-08-010, designating the California Energy Commission (CEC) as a research fund administrator. This program supports energy-related research, development, and demonstration not adequately provided by competitive and regulated markets. These gas research investments spur innovation in energy efficiency, renewable energy and advanced clean generation, energy-related environmental protection, energy transmission and distribution, and transportation.

The CEC's Energy Research and Development Division conducts this public-interest gas-related energy research by partnering with research development and demonstration entities, including individuals, businesses, utilities, and public and private research institutions. This program promotes greater reliability and lower costs, increases safety for Californians, and is focused on these areas:

- Building Decarbonization
- Gas System Decarbonization
- Industrial and Agricultural Innovation
- Transportation
- Resiliency, Health, and Safety
- Entrepreneurial Ecosystem

Mindful Gas Decommissioning: A Data-Driven Tool for Equitable Exploration of Gas Distribution Pipeline Decommissioning in California is the final report for the Data-Driven Tool to Support Strategic and Equitable Decommissioning of Gas Infrastructure project (PIR-22-002) conducted by DNV Energy Insights, Inc. and the UCLA California Center for Sustainable Communities. The information from this project contributes to the CEC Energy Research and Development Division's Gas Research and Development Program.

For more information about the Energy Research and Development Division, please visit the [CEC's research website](http://www.energy.ca.gov/research/) (www.energy.ca.gov/research/) or [contact](mailto:ERDD@energy.ca.gov) the Energy Research and Development Division at ERDD@energy.ca.gov.

ABSTRACT

This report presents the development and outcomes of the Mindful Gas Decommissioning project, which created the Gas Distribution System Screening Tool to support strategic and equitable decommissioning of fossil gas distribution pipelines in California. In response to state climate mandates and policies such as Senate Bill 350, Assembly Bill 3232, and Senate Bill 1221, the project addresses the urgent need for informed planning to transition away from fossil fuels while minimizing cost burdens and equity risks for vulnerable communities.

The data-driven tool employs a Geographic Information System-based multi-criteria decision analysis framework to convey information on pipeline conditions, community impacts, and readiness for clean energy alternatives. It integrates technical and demographic geospatial data, enabling decision-makers to screen for and prioritize promising sites for gas asset decommissioning based on safety, equity, and cost-effectiveness. Key results demonstrate that the tool's Equity Index effectively highlights disadvantaged and underserved communities, to enable decommissioning and community outreach efforts to identify and hone in on areas with the greatest socioeconomic vulnerability, pollution burden, climate risk, and energy inequities.

Extensive stakeholder and community engagement—including workshops, advisory committees, and case studies—shaped the tool's development and validated its metrics. The project's knowledge transfer activities facilitated gaining traction with state agencies, utilities, and community organizations.

The tool provides a transparent, replicable framework to support long-term gas planning, aiding California's decarbonization goals and advancing a just energy transition.

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EXECUTIVE SUMMARY

Background

The California Energy Commission funded this research project in 2022¹ to research and develop the Gas Distribution System Screening Tool (the tool) in alignment with State policies requiring a strategic and equitable transition away from fossil gas. California's climate mandates—such as Senate Bill 350 (Clean Energy and Pollution Reduction Act), which set aggressive greenhouse gas reduction and energy efficiency targets; Assembly Bill 3232 (Building Decarbonization)—along with California Public Utility Commission's Long-Term Gas Planning proceedings (R.20-01-007 and R.24-09-012), emphasized the need for tools that integrate technical and community geospatial data to guide safe and cost-effective decommissioning. These directives, as well as a growing body of literature (Gridworks, 2019, Aas et al., 2020, Gold-Parker et al., 2024, Smillie et al., 2024, Fournier, Pincetl & Smithies, 2025, and National Academies, 2021) highlight the urgency of planning for declining gas demand to avoid disproportionate cost burdens and equity risks. Importantly, Senate Bill 1221, enacted in 2024 after this research project started, reinforced this need by requiring the California Public Utilities Commission to designate priority neighborhood decarbonization zones and create a voluntary program for cost-effective gas system transition. Together, these policies underscore the importance of the tool as an important step toward informed, equitable decision-making aligned with California's 2045 carbon neutrality goal.

Project Purpose and Approach

California is committed to decarbonizing its energy system by reducing its dependence on fossil fuels. The state's gas network currently serves residential, commercial, and industrial customers through extensive transmission and distribution pipelines. The purpose of this decommissioning research project was to collect, curate and visualize data that can help to develop a scalable, systematic approach to screen for promising candidate decommissioning sites served by state's distribution gas pipelines. The scope of this project did not include gas transmission pipelines nor production facilities or sites. Without a strategic approach to decommissioning these pipelines, declining customer participation could leave remaining gas ratepayers facing significant financial burdens from ongoing infrastructure costs. For purposes of this research, decommissioning of distribution gas assets refers to the transitioning of homes or businesses away from (natural or fossil) gas to alternative energy/fuel sources. This may require conversion of appliances. Beyond economics, the transition will have varied health, safety, and energy resilience impacts for both those who remain connected and those who disconnect, influenced by factors such as community characteristics, access to clean energy, and geographic conditions.

¹ Through the Gas Research and Development (R&D) Program Fiscal Year 2021-2022 initiative: Development of a Data-Driven, Actionable Tool and Case Studies to Support the Strategic and Equitable Natural Gas Decommissioning.

The Mindful Gas Decommissioning project (the project) aimed to support the state's transition to a clean energy future by developing a data-driven tool to screen for and identify areas of the gas distribution system that merit consideration for strategic decommissioning. Using a geographic information system-based multi-criteria decision analysis framework, the tool supports evaluation of pipeline conditions, potential community impacts, and readiness for clean energy alternatives. The project emphasized safety, equity, and cost-effectiveness, and involves collaboration with technical experts, local governments, and community organizations to evaluate the tool's effectiveness and ensure inclusive and quantitative decision-making.

The approach for the project centered on developing a transparent, data-driven tool that integrates technical and community geospatial data to support strategic and equitable decommissioning of fossil gas distribution infrastructure in California. The team collaborated with the California Energy Commission, investor-owned utilities, and community partners and other stakeholders to identify and collect relevant data, which was curated and then processed using a geographic information system-based multi-criteria decision analysis framework. This approach made it possible to systematically evaluate candidate sites for decommissioning by combining metrics related to gas asset conditions, readiness for decommissioning, and equity impacts.

Throughout development, the tool was refined through iterative community and stakeholder engagement, technical validation, and real-world case studies to ensure its outputs align with both quantitative analysis and local priorities. The result is a robust, adaptable resource that empowers decision-makers to screen for promising decommissioning sites in a way that aligns with safety and cost-effectiveness and is responsive to community needs.

Key Results

The project developed and validated a data-driven, GIS-based screening tool that integrates gas asset conditions, residential and nonresidential decommissioning readiness, and a multifaceted equity framework to support early-stage identification of promising decommissioning locations across California. Through statewide analyses, community workshops, technical advisory committee input, and five detailed case studies, the project demonstrated how combining quantitative indicators with lived experience can surface localized risks, opportunities, and tradeoffs while revealing limitations of census tract level data. The results show that the tool offers a transparent starting point for exploring decommissioning scenarios, highlighting how technical, social, and environmental factors intersect, and underscoring the need for iterative engagement, context specific analysis, and careful interpretation when applying screening outputs in practice.

The tool integrates technical and community geospatial data to support the state in its ability to explore characteristics of promising sites for decommissioning gas assets and it is a first step in a larger research portfolio intended to support collaborative planning for California's gas system in a low-carbon future. The tool could also support balancing (and representing) the concerns of the State's investor-owned utilities, cities and municipalities, community groups, developers, technology vendors, and other regulators.

California communities identified as disadvantaged, underserved, at-risk, or most vulnerable can experience the highest costs, burdens, and cumulative energy and health inequities linked to early gas decommissioning. The primary equity risks associated with early gas system phase-out in California stem from the disproportionate impacts on low-income, disadvantaged, and underserved communities. As higher-income households transition to alternative energy sources, the fixed costs of maintaining the gas infrastructure are increasingly borne by a shrinking pool of remaining users. These remaining customers—often renters, low-income families, and communities of color—are typically the least able to afford the upgrades or changes required to move away from gas. Without targeted financial and policy support, they face rising utility bills, energy insecurity, and the risk of disconnection (Gold-Parker et al., 2024, Aas et al., 2020, Gridworks, 2019). Moreover, these communities already experience higher exposure to indoor and outdoor air pollution due to gas use, which contributes to adverse health outcomes such as asthma and other respiratory conditions (Fournier et al., 2025, E3, 2024). The transition away from gas, if not managed equitably, could exacerbate these health disparities. Additionally, the upfront costs of replacing gas appliances and modifying homes are often unaffordable for these households, making it difficult for them to participate in clean energy programs. Without inclusive planning and sufficient funding, the shift away from gas could deepen existing inequalities in energy affordability, infrastructure quality, and public health outcomes.

The tool's focus is on supporting the screening for sites that are likely to be most ready or beneficial to consider for gas decommissioning, however, it may also provide insight into unintended – largely positive – community impacts associated with gas system decommissioning. Recognizing and exploring these outcomes could help the State better anticipate indirect effects of implementation, including:

- Switching gas-powered appliances (for example, stoves, furnaces) to alternative energy-powered appliances (for example, induction stoves, heat pumps)
- Improvement of comfort and indoor air quality
- Potential reduction of energy bills (for example, energy efficiency measures)
- Ability to reduce dependency on fossil fuels
- Avoidance of stranded asset costs

The tool can serve as a valuable resource to inform evaluation of, on a local and statewide scale, the impacts of policy decisions on the risks and benefits associated with natural gas decommissioning. The tool could support prioritization of areas for more in-depth analysis, whether by focusing on regions that promise the most immediate advantages or by identifying risk factors and potential mitigation solutions in locations that are more difficult to decarbonize.

Knowledge Transfer and Next Steps

The project team successfully executed the Knowledge Transfer Plan to ensure that the analyses, documentation, and findings from the tool were effectively shared with state and

local agencies, utilities, community organizations, and other interested parties. Engagement efforts were extensive and included convening a Technical Advisory Committee to provide critical feedback at key stages. The team also held multiple meetings with investor-owned utilities, municipal utilities, community choice aggregators, and regional energy networks to align the tool with operational and planning needs.

In total, the project delivered more than a dozen structured knowledge transfer activities, including advisory meetings, public events, and industry briefings. Public engagement included two major workshops in 2023 and 2024, attracting broad participation from community representatives and policymakers. Demonstrations of the beta version of the tool for California Energy Commission and California Public Utilities Commission staff were held in late 2024 and early 2025. The project team held a final public webinar on October 8, 2025, to showcase the tool. The team also conducted a targeted handover session for state agency staff on October 25, 2025. Outreach was amplified through dedicated web resources, fact sheets, and community workshops. These efforts established a strong foundation for adopting and applying the tool to advance California's equitable gas decommissioning strategies.

Benefits to Ratepayers

The tool offers several key benefits to California ratepayers by supplying statewide datasets and data driven metrics that help explore options for achieving a more reliable, cost-effective, and equitable energy transition. First, it supports the strategic prioritization of gas infrastructure decommissioning, helping utilities and policymakers identify areas where decommissioning is most promising to be both economically and environmentally advantageous. This prioritization includes evaluating operator costs, potential reductions in greenhouse gas emissions, and the feasibility of switching to electric appliances—all of which can lead to lower energy bills and improved indoor air quality for ratepayers.

Second, the tool incorporates community engagement through briefings, surveys, workshops and case study development, ensuring that the screening process for promising decommissioning sites reflects local concerns and equity considerations. This will help protect vulnerable ratepayers and ensure that energy equity measures are targeted where they are most needed.

Finally, by providing a transparent and replicable framework, the tool supports long-term planning and cost management for investor-owned utilities, reducing the risk of stranded assets and improving overall energy system reliability. In doing so, the tool empowers California to move toward its decarbonization goals while delivering tangible benefits to the communities it serves.

Chapter 1:

Introduction

Project Purpose

The purpose of this decommissioning research project was to collect and visualize data that can help to develop a scalable, systematic approach to screen for promising candidate decommissioning sites served by the state's distribution gas pipelines. The scope of this project did not include gas transmission pipelines nor production facilities or sites.

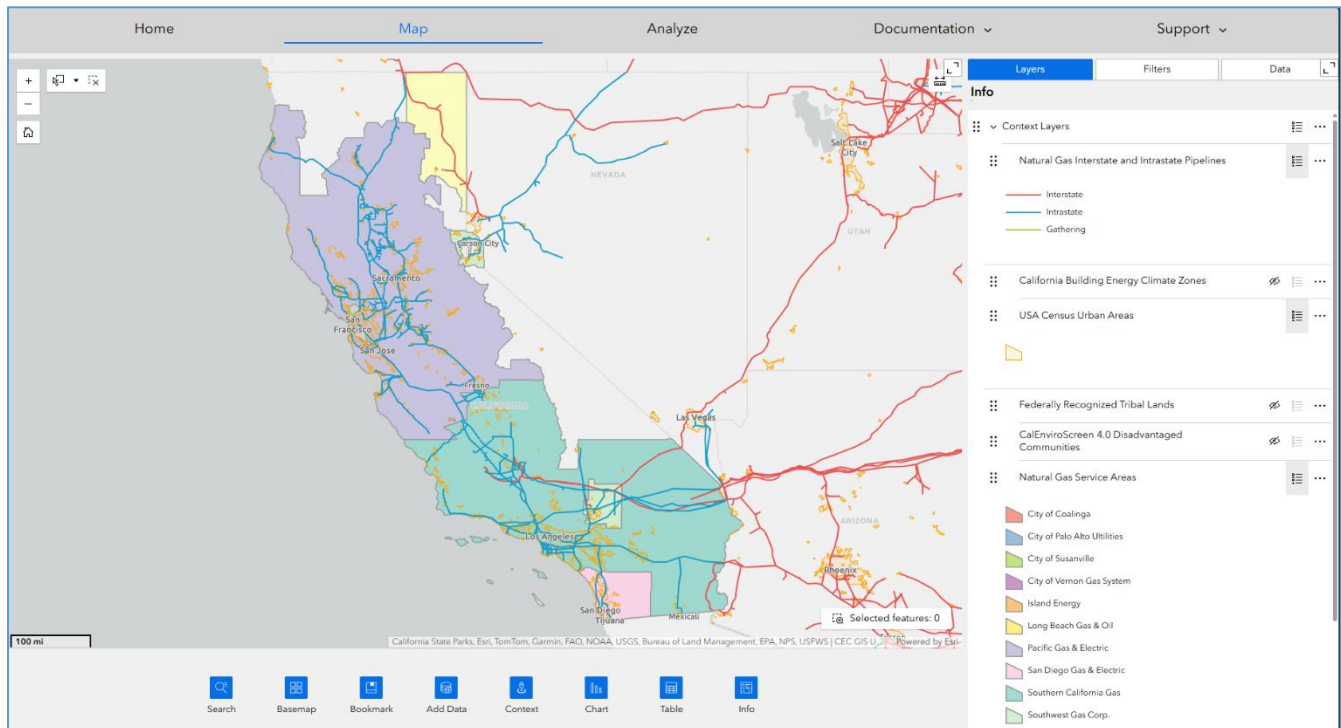
The State of California is committed to decarbonizing its energy system. Decreasing its reliance on fossil fuels is vital to achieving this goal. The gas network provides fossil fuels to residential, commercial, and industrial customers through transmission and distribution pipelines. If a substantial fraction of customers is removed from this system without the strategic decommissioning of gas pipelines, there may be considerable negative financial impacts on the customers remaining on the network, due to the costs of maintaining the pipeline infrastructure.

Further, there will be both positive and negative impacts on the health, safety, and energy resilience of both the customers who remain on the network and those who decommission. These impacts will depend on a range of factors including community characteristics, local access to clean energy, safety risks, infrastructure conditions, cost-effectiveness, and environmental justice indicators. The focus of this project is to quantify and integrate these various factors and present them in a visual, data-driven Gas Distribution System Screening Tool (the tool) that integrates technical and community geospatial data to help policymakers and stakeholders assess trade-offs, test scenarios, and make informed decisions in the face of competing priorities. By incorporating equity metrics and community input, the tool ensures that decommissioning strategies could be strategic, as well as locally and socially responsive, advancing California's goals for an equitable energy transition.

Background Information

This research was funded to develop a data-driven approach to screen for promising sites for gas decommissioning through a map-based tool that leverages gas system data and publicly available community data. While later policies, such as Senate Bill (SB) 1221 in 2024, reinforced the need for neighborhood-scale decarbonization, the start of this project marked an early step toward informed planning aligned with California's 2045 carbon neutrality goal. California's natural gas infrastructure currently serves more than 11 million meters and spans more than 100,000 miles. This vast network must be decommissioned in a way that is safe, intentional, environmentally just, and cost-effective. Figure 1 is a screen capture from the resulting tool that conveys the magnitude of the infrastructure and the challenge of statewide decommissioning.

Figure 1: California Gas Distribution Transmission System Map



Screen capture from the internal decommissioning planning tool, illustrating the scale and complexity of the statewide infrastructure network. This vast system must be decarbonized in a manner that is safe, intentional, environmentally just, and cost-effective.

Source: Screenshot from the Gas Distribution System Decommissioning Screening Tool – Map module

Project Goals and Objectives

Decarbonizing California's energy system requires drawing down natural gas emissions, promoting behavioral shifts in energy usage, and expanding access to carbon-free energy through strategic deployment of clean energy technologies. Technological barriers to decarbonizing energy resources have been largely overcome (National Academies, 2021). Addressing the remaining political, social, and techno-economic barriers, however, requires data-driven approaches. This tool was designed to help overcome those barriers by supporting the identification of gas distribution system areas that merit consideration for strategic decommissioning.

The goal of this project was to develop a tool and the data utilized within it that could provide an entry point to conversations about decommissioning and the associated risks and benefits. Developing the tool was a first step to efficiently screen for promising sites for more detailed and targeted analysis of the technical feasibility of decommissioning specific segments of the gas system. The overall goal of this project was to develop the tool using data collected through the State's existing programs, public data sources, and data collected in partnership with investor-owned utilities (IOU), municipalities, and other stakeholders. The tool was not intended to deliver definitive decisions about pipeline decommissioning; rather, its purpose is to provide an initial screening platform that translates complex data into actionable insights

and supports early-stage conversations about the risks, benefits, and feasibility of decommissioning in different locations across the State.

To achieve this goal, the research team focused on developing a data-driven tool that:

- Enables screening for promising sites for decommissioning
- Provides a first step for prioritizing more targeted analysis of the technical feasibility of decommissioning specific segments of the gas system
- Incorporates data for considerations of safety, equity, readiness, and cost-effectiveness

The project sought to integrate data related to safety, equity, readiness, and cost-effectiveness using publicly available sources and partner-provided information. The aim was to create a framework that could help decision-makers compare locations, understand trade-offs, and prioritize where more detailed, site-specific technical analysis should be directed.

- Collectively, these objectives guided the design of a tool intended to support data-driven decision-making and lay the groundwork for an equitable, scalable approach to identifying potential natural gas decommissioning opportunities across California.
- One of the goals for developing this tool was to take a more expansive view of different classes of costs/benefits that are not readily convertible to dollars and cents, and thus seldom formally considered in site screening/prioritization exercises. Throughout this report, references to “cost effective” or “cost effectiveness” are descriptive and do not reflect calculations performed by the tool. In this context, “cost effectiveness” means a site- or program-specific assessment conducted outside the tool comparing whose costs (for example, utility capital and operation/maintenance, program costs, and customer costs), relative to what alternative (for example, pipeline replacement vs. targeted electrification and decommissioning), and under what assumptions (for example, time horizon, discount rate, incentives, rate recovery, and equity/affordability considerations).
- The tool itself provides screening indicators (for example, safety, equity, residential/nonresidential readiness) and a cost-related proxy (for example, pipeline replacement cost as part of the Gas Assets Index). It does not produce cost effectiveness metrics, net present value, or cost benefit results. Any determination of cost effectiveness would require separate, site-specific economic analysis performed outside the tool, using the tool’s outputs as inputs to that analysis.

Audience

The tool was developed to support a wide range of stakeholders involved in California’s transition away from natural gas infrastructure. The primary audience for the tool includes state agencies such as the California Energy Commission (CEC) and the California Public Utilities Commission (CPUC), who set policy, evaluate infrastructure investments, and oversee regulatory compliance. IOUs including Pacific Gas and Electric (PG&E), San Diego Gas and

Electric (SDG&E), and Southern California Gas (SoCalGas) are also key potential users who can leverage the tool to identify promising sites for decommissioning and assess technical feasibility, cost impacts, and equity considerations.

Local governments and municipalities represent another important potential user group. These entities can use the tool to understand community-level readiness for transitioning to clean energy systems and to align infrastructure upgrades with local climate action plans. The tool's census tract-level granularity and map-based interface make it accessible to planners and analysts working across diverse jurisdictions.

In addition to institutional users, the tool was designed to support community-based organizations (CBO) and advocacy groups. These stakeholders could use the tool to validate equity metrics and ensure that decommissioning efforts reflect lived experiences and community priorities. Their feedback during the tool's development helped shape its usability and relevance to frontline communities.

The tool can also serve technical and policy advisory committees, academic researchers, and other experts who may use its methodology and outputs to inform future studies and policy evaluations. Its modular design allows for updates and customization, ensuring that it remains responsive to evolving data sources and stakeholder needs.

By aggregating and normalizing data across multiple domains—including infrastructure, socioeconomics, and energy systems—the tool enables collaborative, data-driven decision-making. It is intended to facilitate transparent planning processes that balance technical feasibility with equity and community impact.

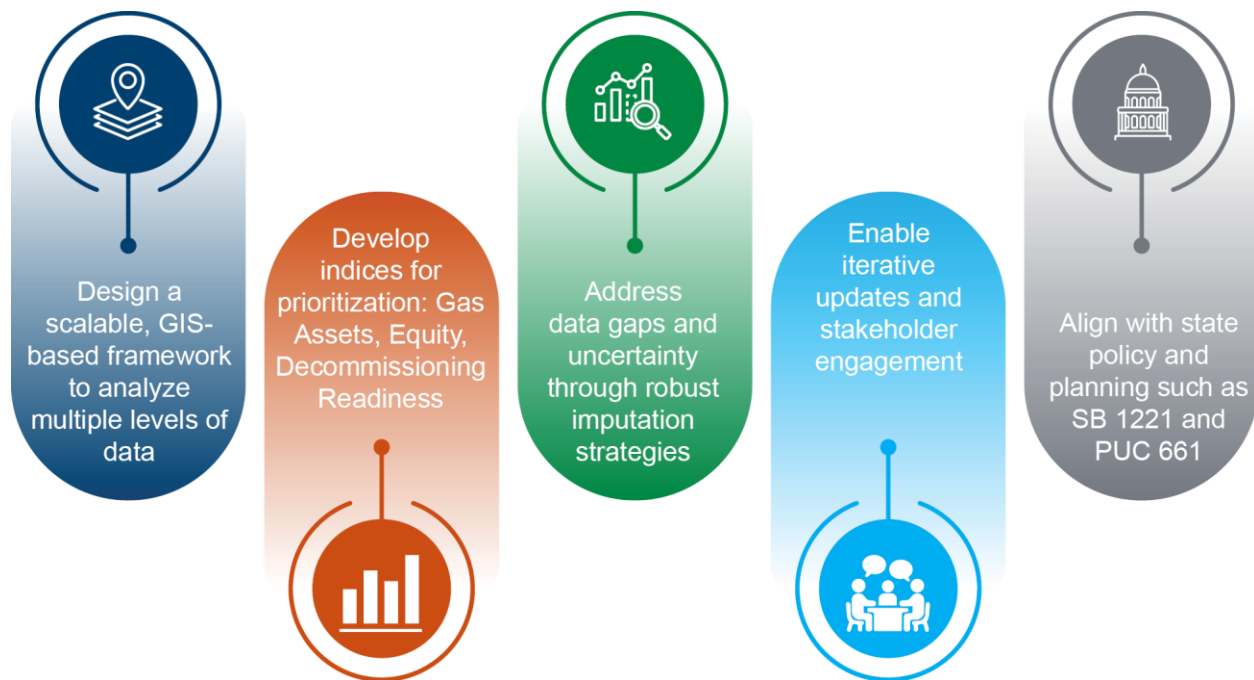
Chapter 2:

Project Approach

Research Objectives

Working with various stakeholders (listed in the Acknowledgement section) the team developed a transparent, replicable, and scalable tool to support the assessment of promising sites for strategic natural gas decommissioning. Specific research objectives are summarized in Figure 2 and discussed in more detail below. See the “Methodology” section of Chapter 2 for a more detailed description of the methodology applied to achieve these research objectives.

Figure 2: Summary of Research Objectives



Summary of the project’s research objectives developed through collaboration with multiple stakeholders. These objectives guided the creation of a transparent, replicable, and scalable tool for assessing promising sites for strategic natural gas decommissioning.

Source: Mindful Gas Decommissioning Research Team

Design a Scalable, Geospatially Driven Framework. The project aimed to develop a decision-support tool capable of ingesting and analyzing geospatially resolved datasets. These included pipeline infrastructure data, community demographics, parcel-level and block-level data, socio-economic indicators, and electricity grid characteristics. The final tool features a map-first interface that enables dynamic spatial queries and overlays multiple index layers to support statewide assessments.

Develop Indices for Screening Prioritization. To guide strategic decision-making, the research focused on constructing standardized indices:

- Gas Assets Index: Evaluates infrastructure age, leak risk, regulatory alignment, and cost implications.
- Equity Index: Measures socioeconomic vulnerability, pollution burden, energy burden, climate risk, environmental risk, sensitive populations, and access to critical services.
- Decommissioning Readiness Index: Assesses the technical and economic feasibility of transitioning away from gas in residential and non-residential (commercial) sectors.

Each index was normalized and scored at the census tract-level to enable comparative analysis across diverse regions.

Address Data Gaps and Uncertainty. The research team developed robust imputation strategies, where possible, using publicly available census tract-level data to address limitations in data availability (further descriptions provided in this report). The tool incorporates uncertainty propagation methods to ensure reliable output even in data-sparse environments.

Enable Iterative Updates and Stakeholder Engagement. The tool was designed to be modular and updatable, allowing for the integration of new data and stakeholder feedback. The project included a multi-pronged engagement strategy involving technical and policy advisory committees, community workshops, and case study partnerships to ensure the tool's relevance and usability across diverse contexts.

Align with State Policy and Planning Frameworks. The research team intentionally designed the tool to align with the goals and requirements laid out by California's long-term gas planning efforts, including SB 1221 and Public Utilities Code (PUC) 661 mandates. The tool's indices and mapping capabilities support the ability to carry out initial screening for potential pilot site areas, as well as exploration of scenarios associated with long-term gas planning efforts, providing a foundation for equitable and cost-effective infrastructure transition.

Project Partners and Participants

This section includes detailed descriptions of the key project partners (DNV, University of California, Los Angeles [UCLA], and Self-Help Enterprises) and their roles, responsibilities, and contributions to the project and development of the tool. It also includes a list of the Technical Advisory Committee (TAC) members who helped validate data types and sources and advised the project team on tool development as well as the community partners that assisted in developing place-based case studies to ground truth collected data with community knowledge and lived experience.

DNV

DNV served as the lead research and implementation partner for this research, working in close collaboration with CEC staff and UCLA's California Center for Sustainable Communities (CCSC). The project aimed to develop a transparent, replicable, and scalable data-driven tool

to support strategic decision-making around natural gas infrastructure decommissioning across California.

DNV led the technical design and delivery of the tool, integrating geospatially resolved datasets to assess pipeline integrity, community vulnerability, and infrastructure readiness. DNV developed composite indices—including the Gas Assets Index, Equity Index, and Decommissioning Readiness Index—each normalized at the census tract level to enable comparative analysis. These indices provided a structured framework for exploring and supporting evaluation of decommissioning feasibility, equity impacts, and infrastructure risk.

To address data limitations, DNV implemented imputation strategies and uncertainty propagation methods, ensuring the tool could operate effectively even in data-sparse environments. The tool was designed to be modular and updatable, allowing for integration of new data and stakeholder feedback over time.

The project team managed cross-functional collaboration across analytics, climate equity, stakeholder engagement, and technical modeling. DNV coordinated stakeholder engagement efforts, facilitating workshops, webinars, and case study partnerships with community-based organizations, who served as policy experts and co-researchers. These engagements helped validate the tool’s metrics and supported its design so that it was both relevant to diverse communities and attuned to policy developments (such as SB 1221 and PUC 661).

UCLA’s California Center for Sustainable Communities

UCLA’s CCSC served as a co-lead research institution in developing the tool, collaborated closely with DNV and the CEC to ensure the tool was grounded in robust methodology, community relevance, and policy alignment.

UCLA’s primary contributions centered on the tool’s architecture, hosting strategy, and interface design, with a particular focus on geospatial mapping and the integration of contextual layers such as climate zones, tribal lands, and disadvantaged communities. The team led the development of the Decommissioning Readiness Indices which support evaluation of technical and economic feasibility of transitioning away from natural gas, separately, among residential and non-residential customer sectors. The indices were scored at the census-tract level to support comparative analysis statewide.

In addition to technical development, UCLA played a key role in stakeholder engagement. The team coordinated live demonstrations of the tool during workshops and webinars, showcasing its interactive features and layered indices to state agencies, IOUs, and municipalities. UCLA also led place-based case studies and worked directly with community-based organizations to ensure the tool reflected lived experiences and local priorities.

UCLA was responsible for producing core documentation, including the user manual, tool guidance materials, and final report contributions. These deliverables detailed the design rationale, data methodology, and equity considerations embedded in the tool. The team also supported long-term usability by developing a product management plan and a technology transfer strategy which was delivered to the CEC’s agreement manager.

Technical Advisory Committee Members

The project's TAC members supported validating data types and sources and advised the research team on the tool development. The TAC members were part of the following organizations:

- Natural Resources Defense Council
- Energy Coalition
- Stanford University
- Energy+Environmental Economics (E3)
- RAND
- CPUC
- CEC

Community engagement with the TAC is described in more detail in the "Community Engagement, Case Studies, and Resource Hub" section of Chapter 3.

Community Partners

The following organizations served as full case-study partners, working with the research team throughout the complete development process. In addition to these primary partners, the research team also engaged several other CBOs that expressed interest in the project. However, due to funding and capacity constraints, engagement with these groups was limited to a small number of meetings. While many of these organizations demonstrated interest in issues related to gas decommissioning, they were unable to sustain deeper participation given competing organizational and community priorities. Development of the case studies is described in more detail in the "Community Engagement, Case Studies, and Resource Hub" section of Chapter 3.

- Blue Lake Rancheria, North Coast/Humboldt
- Central California Asthma Collaborative, Central Valley
- Climate Resilient Communities, North Fair Oaks
- Climate Ready North Fair Oaks
- Staff and community leaders at Climate First: Replacing Oil & Gas (CFROG), Oxnard
- Restore the Delta, Stockton
- Self-Help Enterprises, San Joaquin Valley

Methodology

The research team designed the project methodology to:

1. Identify primary data needs in conjunction with the CEC, communities, and other stakeholders.

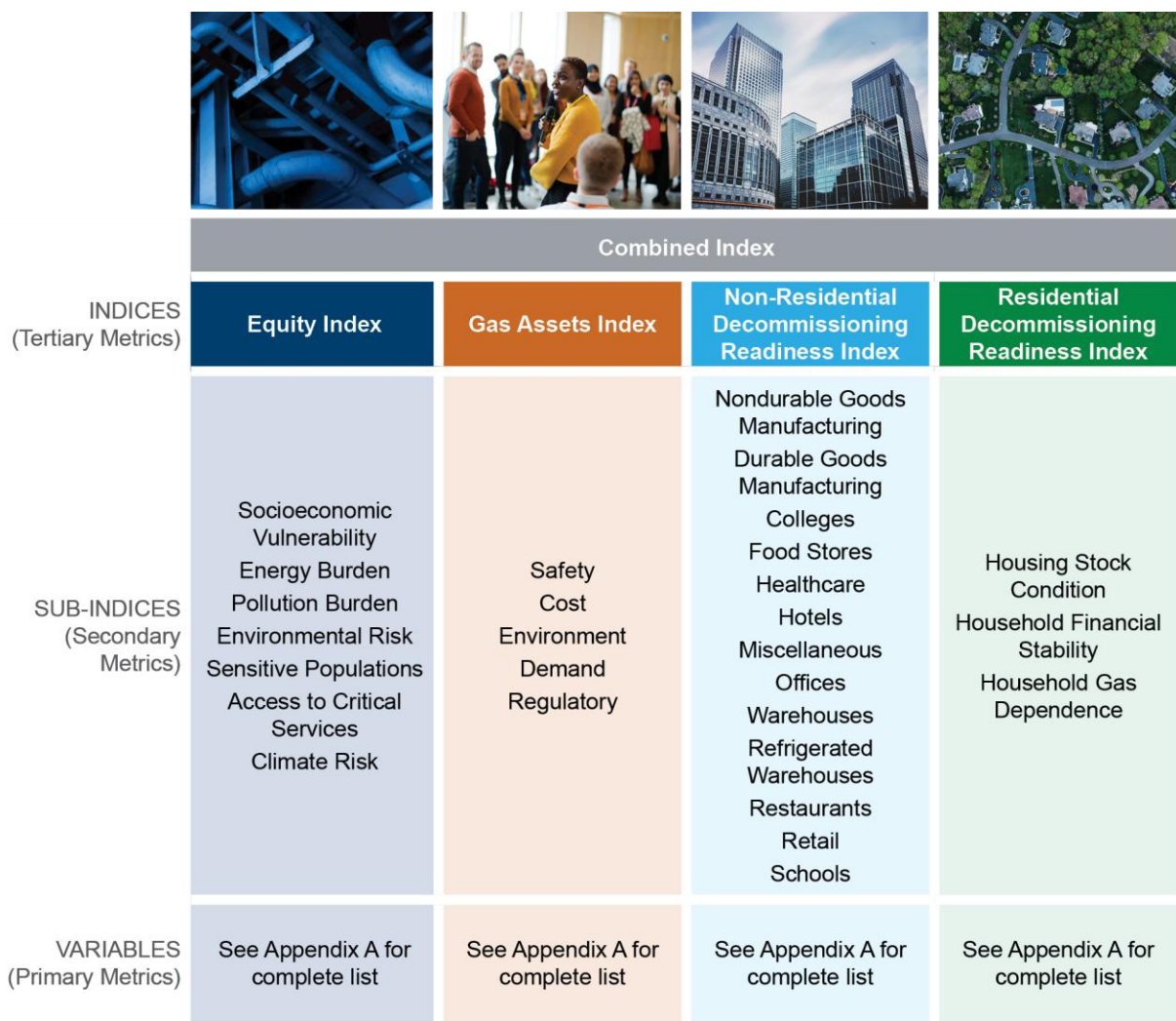
2. Collect, synthesize, and protect data, including creating standard data formats and generalized representations, and synthesizing data into indices and sub-indices that effectively communicate the geospatially-dependent risks and benefits of decommissioning.
3. Design and test the data-driven tool to identify priority geographic locations for possible natural gas decommissioning relative to multiple simultaneous objectives.

Overview of Indices and Sub-Indices

In developing the tool to support strategic and equitable decommissioning of gas infrastructure, the DNV team coordinated closely with CEC staff and other stakeholders to develop indices and sub-indices that summarize the metrics collected in Task 2-Gas Assets Assessment, Task 3-Decommissioning Readiness, and Task 4-Community Resources and Equitability Assessment.

Figure 3 lists the indices, sub-indices, and variables, illustrating the relationship between these metrics. To see a complete list of variables mapped to indices and sub-indices refer to APPENDIX A. Additionally, the research team provided the CEC with a Secondary and Tertiary Metrics Report containing additional detail about the development of the indices, sub-indices, and variables. This report is listed in the “Project Deliverables” section at the end of this report.

Figure 3: Mapping of Indices, Sub-indices, and Variables



Indices, sub-indices, and associated variables developed to support the tool for strategic and equitable gas infrastructure decommissioning. In close coordination with CEC staff and other stakeholders, the DNV team organized metrics into a structured framework that summarizes their relationships.

Source: Mindful Gas Decommissioning Research Team

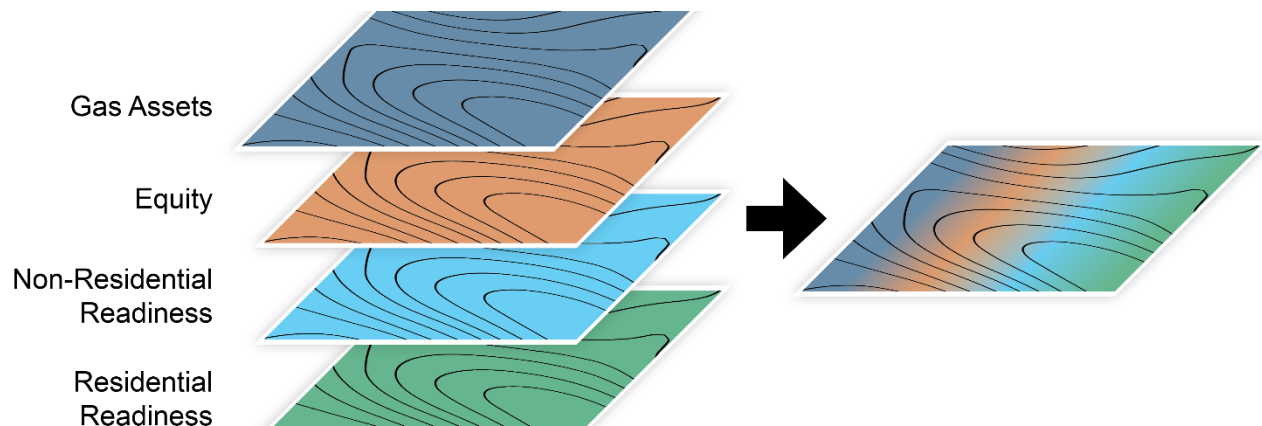
Index and Sub-Index Development Methodology

The tool employs a geographic information system multi-criteria decision analysis (GIS-MCDA) framework (Malczewski & Rinner 2015). This is a well-established approach to geospatial site selection processes—that allows for the combination of diverse data layers representing the physical condition and risk characteristics of gas assets, technical and social dimensions of decommissioning readiness, and a broad spectrum of equity impacts. This technique combines multiple pieces of quantitative information into a single unified representation, even when they are naturally represented using diverse units and scales or derived from different sources. The layers represent groupings of primary variables relevant to gas decommissioning site exploration, including considerations related to energy equity and environmental justice, the condition of gas distribution infrastructure assets, the volume of gas consumed by non-

residential gas customers, and potential barriers to gas substitute technology adoption among residential customers.

Figure 4 illustrates how the tool integrates geospatial data and multi-criteria decision analysis to support planning. As shown, the tool is organized around the four indices—Gas Assets, Equity, Non-Residential Decommissioning Readiness, and Residential Decommissioning Readiness—and use of the GIS-MCDA Framework enables disparate data to be viewed together on the same scale to support complex decision-making and tradeoff assessment.

Figure 4: GIS-MCDA Framework



Integration of geospatial data and multi-criteria decision analysis (MCDA) within the tool to support strategic planning. The tool organizes inputs around four indices and applies the GIS-MCDA Framework to place diverse datasets on a common scale. This enables users to evaluate complex tradeoffs and make informed decisions about decommissioning pathways.

Source: Mindful Gas Decommissioning Research Team

A challenge associated with constructing and delivering the tool was to create an entirely new set of metrics with the power to convey in succinct, intuitive ways some key risks and benefits of natural gas decommissioning to IOUs, ratepayers, and disadvantaged communities. The data sets included in the tool came from a wide range of sources in a variety of formats and with different levels of geographical precision. The research team constructed common data formats and representations for variables, sub-indices, and indices, and developed methods for converting the data sets from public or private data sources into the data formats that are most amenable for the tool's applications.

Using the GIS-MCDA framework, the research team developed geospatial layers in four steps.

1. Primary input data layers (variables) were obtained from a combination of public and private sources accessible by the project team members.
2. Variables were reviewed for quality and completeness and, where needed, variables were imputed, derived, and/or aggregated to prepare the dataset for Step 3.

3. Secondary layers (sub-indices) were developed using a consistent geographic unit of aggregation- the census tract, to reflect each independent criterion/factor involved in gas network decommissioning.²
4. Sub-indices were used to create a combined index layer that conveys an overall assessment of gas decommissioning risks, costs, and benefits.

This Methodology section provides a comprehensive overview of the foundational principles and processes that guided the development of the tool. Table 1 provides high-level overview of the tool development process and methods.

Table 1: Tool Development Process Methodology Overview

Step	Process	Methodology
1	Identify and source data (for each of the four indices)	• Secondary research and literature review • Engagement with technical advisors and stakeholders • Engagement with communities
2	Prepare data (for each of the four indices)	• Quality control: review data quality and completeness • Imputation: Impute missing values where possible • Derivation: Use available inputs to derive new variables where needed • Aggregation: Address any privacy concerns by aggregating data where needed
3	Derive sub-indices (for each of the four indices)	• Value scaling • Fisher-Jenks optimization • K-means clustering • Criteria weighting
4	Derive combined index	• K-means Clustering • Weighting considerations

Source: Mindful Gas Decommissioning Research Team

The following sections describe the data sourcing and preparation processes, and the specification and creation of variables and sub-indices for each index (steps 1-3 in Table 1) as

² Census tracts are geographic units created by the [U.S. Census Bureau](https://www.census.gov) whose population sizes are meant to be both statistically representative and equivalent. The target population size for tracts is 4,000 people with a minimum of 1,200 and a maximum of 8,000. <https://www.federalregister.gov/documents/2018/11/13/2018-24567/census-tracts-for-the-2020-census-final-criteria>

follows: Equity Index, Gas Asset Index, Non-residential Decommissioning Readiness Index, and Residential Decommissioning Readiness Index. Key concepts—such as data integration, analytical transparency, stakeholder engagement, data security, scalability, adaptability, and validation—are discussed in detail to provide readers with an understanding of how these elements underpin the tool’s design and implementation.

Equity Index

Data Representations and Metrics

The research team engaged CBOs along with other local stakeholders, including neighborhood groups, and community advocates, to gain a broader range of community perspectives and validate the data in the tool. This engagement focused on assessing community “readiness” for gas decommissioning, defined in this project as the broader community socio-economic and environmental conditions and vulnerabilities that support or hinder a community’s ability to transition to non-gas alternatives, rather than the retirement or removal of gas pipelines.

To more fully understand communities’ perspective and their potential readiness to decommission, this required a holistic assessment of the community’s income profile, median home age, level of support for climate action initiatives, and so on. The research team conducted community workshops to determine which quantitative metrics should be developed and integrated into the decommissioning assessment.

An Equity Index was developed, comprising of seven sub-indices, each informed by a set of relevant primary variables. These variables were identified and compiled to represent community impacts and investigate pathways to identify and prioritize California communities most vulnerable to costs, burdens, risks and distributional inequities associated with gas decommissioning. These considerations include potential unintended consequences such as stranded asset costs, which can arise when declining use of the gas system leaves utilities with unrecovered investments in pipelines and other distribution infrastructure, shifting a growing share of fixed system costs onto a shrinking customer base. Communities that face barriers to adopting non-gas alternatives—due to factors such as socioeconomic constraints, rental housing dynamics, or housing condition—may therefore become disproportionately exposed to rising energy costs and rate increases tied to ongoing safety and maintenance requirements. As some areas transition to non-gas options more quickly, later-transitioning or historically underserved communities can face inequitable financial impacts, which may compound existing vulnerabilities and, in some cases, might (for example) interact with broader housing pressures to heighten displacement or gentrification risks.

The variables identified as part of this research are intended to uplift non-energy impacts and benefits (for example, health, housing, jobs) that communities prioritize, as validated through feedback gained through broader community and stakeholder engagement and the more targeted case study process and to a certain extent technical and subject matter experts.

Methodology and Rationale

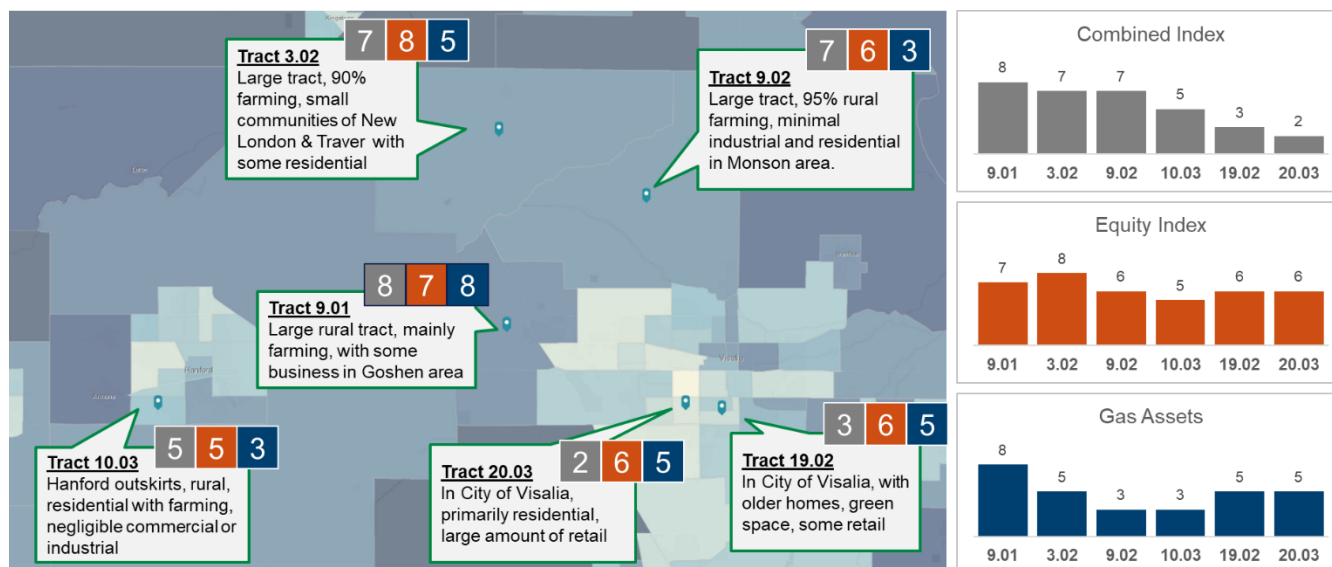
Through a desktop research process, the team reviewed publicly available equity frameworks and screening tools to identify indicators that meaningfully relate socioeconomic and environmental conditions to potential impacts of gas decommissioning. Indicators were

selected based on their relevance to known pathways of inequity in the gas transition—such as disproportionate exposure to environmental burdens, sensitivity to cost shifts, or vulnerability to service disruptions—and were compiled into a comprehensive list representing community impacts. These indicators then served as the foundation for the development of the tool’s equity-related indices, supporting the identification of promising decommissioning candidate sites statewide.

The resulting rationale as expressed in the tool is that, for example, if a region scores high in the Sensitive Populations, Environmental Risk, and Climate Risk sub-indices, it may be considered a promising candidate for early gas decommissioning to help address these risks and related inequities sooner rather than later—provided there are no conflicting results in the Gas Assets and Decommissioning Readiness Indices. For example, if during a screening with the tool, an area ranks high on the Equity Index but scores very low in the Gas Assets and Decommissioning Readiness Indices, it may be de-prioritized in favor of a location that scores high across all three categories. Additionally, even within the Equity Index itself, certain factors may influence prioritization decisions. An area with high energy burden and frequent grid outages, for instance, may not be a strong candidate for early decommissioning, as the transition to alternative energy sources could increase energy insecurity in the short term.

Figure 5 below provides an example of the overall and index-level scores for six census tracts across two cities in California that represent a diverse mix of rural and urban areas, with both shared and distinct challenges. This figure serves as an example of a “bottom up” use of the tool, where it can be used to gain a better understanding of the implications of the gas transition for communities. One of the key strengths of the tool is that low and high census tract scores do not just flag barriers and strengths—they uncover local complexities and highlight where further engagement and analysis are needed. Used at the local level, the tool can help identify potential tensions between considerations such as safety and residential readiness, as well as high socio-economic vulnerability and energy burden. Once such dynamics are visible, decision makers are better informed to make choices that balance cost, safety, and overall readiness against equity.

Figure 5: Comparison of Index Scores Across Rural and Urban Census Tracts



Example of overall and index-level scores for six census tracts across two California cities representing a mix of rural and urban contexts with both shared and distinct challenges.

Source: Mindful Gas Decommissioning Research Team

In contrast, a top-down use of the tool could assist the State in efficiently identifying locations with the highest overall readiness scores for decommissioning across the four indices. These areas can subsequently be designated as preliminary priority census tract areas for consideration, or users can leverage the tool's detailed layers to more deeply analyze local demographic, infrastructural, and environmental characteristics.

Data Resources and Sub-Index Detail

The process for using a data-driven scoring system to evaluate and rank different areas of the state (by census tract), as in this tool, is described in the Value Scaling section. The aggregated data in the tool was reviewed and analyzed to determine clusters or patterns of community impacts. For instance, the Sensitive Populations sub-index was regressed with other indices to determine clusters and/or patterns that might emerge based on characteristics such as urban vs. rural vs. indigenous lands. The analysis informed the case study profiles that are representative of regions and areas throughout the state. These profiles served as a foundation for a broader understanding of regional differences and priorities, particularly in relation to equity and environmental justice. This case study approach informed a statewide understanding to help determine the unique environmental justice and energy equity-focused needs and interests in various regions in the state. This case study process and community validation of the respective indices are described in more detail in the deliverable *Community Resources and Equitability Assessment Report* (also listed in the "Project Deliverables" section).

The sub-indices and variables for the Equity Index are shown in Table 2. Variable descriptions are included in APPENDIX B: Variable Descriptions.

Table 2: Variables to Sub-Indices for the Equity Index

Sub-Index	Variable	Data Source
Socioeconomic Vulnerability	• Education • Linguistic isolation • Poverty line • Mobile homes • People of color • Rent burden • Renter status • Single parent • Unemployment rate	U.S. Census Bureau American Community Survey 5-Year (ACS 5-Year 2018-2022), last accessed March 11, 2025
Energy Burden	• Income to energy bill ratio • Non-grid fuels³	ACS 5-Year 2018-2022
	• Grid outage duration • Grid outages county	U.S. DOE Low-income Energy Affordability Data (LEAD) Tool, retrieved July 28, 2023
Pollution Burden	• Diesel particulate matter • Ozone concentrations • Pesticides use • PM2.5 concentrations	CalEnviroScreen 4.0, retrieved July 28, 2023
	• Toxic releases to air	U.S. Environmental Protection Agency (EPA) Environmental Justice Mapping and Screening Tool (EJScreen), retrieved July 28, 2023

³ Many low income, rural, and disadvantaged communities rely on non-grid fuels such as propane, fuel oil, kerosene, wood, or biomass. Including these fuels into analyses is important because their use can often impose higher and more volatile energy costs, contribute to indoor air pollution and other health and safety risks, and can dominate total household energy burden. Without accounting for non-grid fuels, communities with low gas use may appear less burdened than they truly are; incorporating them helps capture the full cost of energy rather than only grid- based sources.

Sub-Index	Variable	Data Source
Environmental Risk	- Asbestos risk - Lead paint	ACS 5-Year 2018-2022
	- Hazardous waste proximity - RMP proximity - Superfund proximity - Underground storage tanks proximity - Wastewater discharge	U.S. EPA EJ Screen
	Soil contamination	CalEnviroScreen 4.0
Sensitive Populations	- Asthma incidence - Heart disease incidence - Percent Low birth weight	CalEnviroScreen 4.0
	- Cancer incidence - Percent Low life expectancy	U.S. EPA EJ Screen
Access to Critical Services	Food deserts	U.S. Department of Agriculture (USDA) Food Access Research Atlas, retrieved March 11, 2025.
	Housing burden	CalEnviroScreen 4.0
	- Limited broadband - Health insurance	U.S. EPA EJ Screen
	Transportation stops	Inter-university Consortium for Political and Social Research (ICPSR) National Neighborhood Data Archive (NaNDA): Public Transit Stops by Census Tract and ZIP Code Tabulation Area, United States, 2016-2018 and 2024. Retrieved March 11, 2025.
Climate Risk	- Expected annual loss – agriculture - Expected annual loss – buildings - Expected annual loss – population	Federal Emergency Management Agency (FEMA) Natural Risk Index Dataset retrieved July 28, 2023.

Source: Mindful Gas Decommissioning Research Team

Gas Asset Index

Data Representation and Metrics

The team worked with the TAC and CEC staff to identify factors that impact the risks, costs, and benefits of decommissioning from the perspective of gas distribution system operators. Through literature review and stakeholder engagement, the list of factors assessed and prioritized included environmental, health, and safety risks; hydraulic analysis; financial assessment of stranded asset risk, avoided pipeline replacement costs and operating expense changes; and greenhouse gas (GHG) reductions to be realized by preventing fugitive emissions and decreasing gas use. Though the team could not access gas infrastructure asset-level data (for example, on hydraulic feasibility) for development of this tool, the team was able to use public data sources to assess decommissioning risks, costs, and benefits at the census-tract level. This task provided a statewide perspective on the impacts of decommissioning specific portions of the gas distribution system infrastructure.

The tool uses Gas System Census Tract Data as provided by utilities to the R.20-01-007 service list on November 4, 2022, in compliance with the Long-Term Gas Planning Rulemaking. The five sub-indices included in the Gas Assets index, listed with what each is designed to measure, are:

- **Safety:** risk of gas leaks, explosions, fires, and other hazards associated with the gas distribution pipelines.
- **Environment:** environmental benefits and impacts associated with gas decommissioning.
- **Cost:** cost avoidance associated with gas decommissioning in an area.
- **Regulatory Compliance:** regulatory compliance and alignment associated with gas decommissioning in an area.
- **Demand:** gas demand reduction and customer impact associated with gas decommissioning in an area.

Methodology and Rationale

The research team began by identifying factors that influence decisions on gas distribution system infrastructure decommissioning. As described above, the identified gas asset assessment factors are safety, environment, cost, regulatory compliance, and demand. These five areas were defined as the sub-indices for the gas assets index.

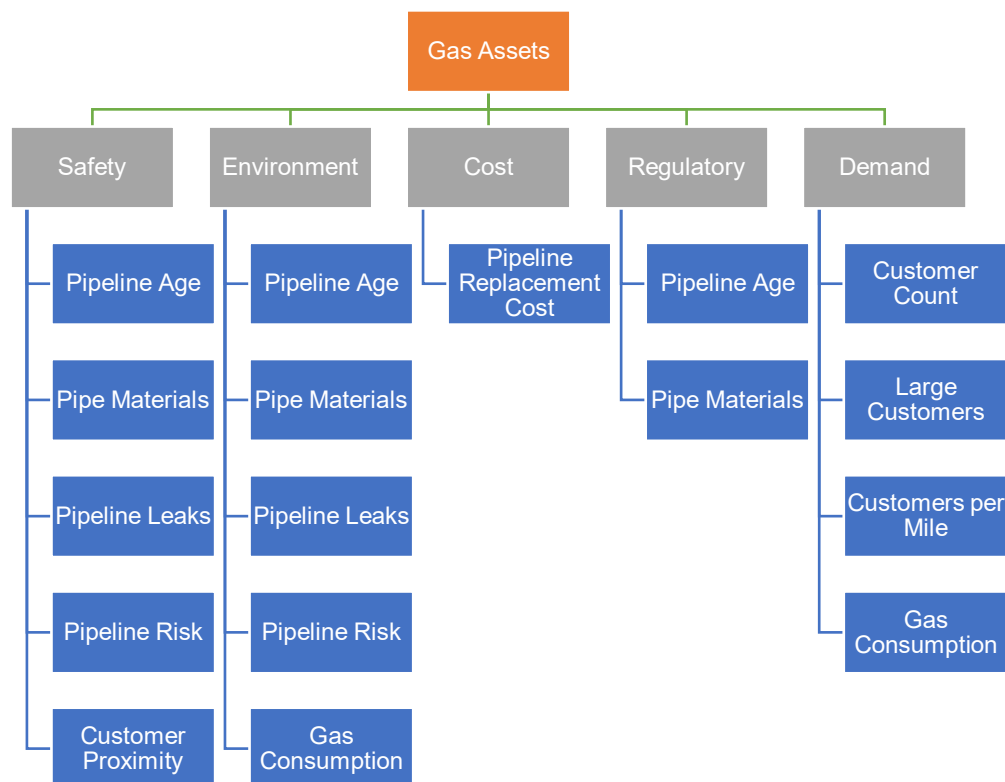
To identify variables associated with each of these areas, the research team started the data exploration by reviewing the Gas System Census Tract Data provided by the four investor-owned gas utilities—PG&E, SoCalGas, SDG&E, and Southwest Gas (SWG)—in response to the CPUC's Long-Term Gas Planning Rulemaking R.20-01-007. Data files for each of the four utilities were accessed and downloaded from the CPUC's website (CPUC, 2024).

Using the R programming language, the files were read and analyzed, with steps taken to validate and clean data to create a single dataset with consistent values across IOUs for each of the fields. For example, data was reviewed and edited where needed to ensure consistent

use of variable names and units of measure. After a thorough review of the available data and fields, the research team identified a subset of variables with sufficient data to be used in the analysis. More information on the data validation and selection process is provided in the project interim deliverable *Gas Assets Assessment Data Collection and Analysis Report*.

As a first step in choosing which variables to use in the model, the team identified gas infrastructure characteristics associated with each of the five sub-indices. These characteristics are anticipated to influence the benefits and risks associated with decommissioning. Figure 6 shows a mapping of gas assets sub-indices (in green) to characteristics (in dark blue). For example, the Gas Assets Safety sub-index shows five characteristics that influence pipeline safety and associated decommissioning benefits and risks: Pipeline Leaks, Pipeline Risk, Pipeline Age, Pipe Materials, and Customer Proximity. These fields are relevant for safety because leak-prone pipes pose a risk to human safety, and the magnitude of risk is increased by the number of customers nearby. Figure 6 also shows reuse of some pipeline characteristics across sub-indices (for example, Pipeline Age and Pipe Materials appear in Safety, Environment, and Regulatory sub-indices; Gas Consumption appears in Environment and Demand sub-indices). This reuse (also easily seen in Appendix A) points to some similarities in what the sub-indices are designed to convey. For example, the Safety sub-index explores the risks to human health and safety, while the Environment sub-index explores risks of environmental damage associated with GHG emissions. Replacing leak-prone pipes has both safety and environmental benefits. The Safety sub-index also considers Customer Proximity, while the Environment sub-index includes Gas Consumption as a measure of overall gas use, which would be proportional to GHG emissions.

Figure 6: Gas Assets Decommissioning Characteristics Grouped by Sub-Index



Mapping of gas asset sub-indices (green) to key infrastructure characteristics (dark blue) used to inform the model. The research team first identified characteristics anticipated to influence the benefits and risks of decommissioning, such as pipeline leaks, pipeline age, pipe materials, pipeline risk, and customer proximity. As illustrated, several characteristics—such as Pipeline Age, Pipe Materials, and Gas Consumption—appear across multiple sub-indices, reflecting overlaps in what the sub-indices are designed to convey.

Source: Mindful Gas Decommissioning Research Team

Working with the IOUs' Gas System Census Tract Data, the team determined which of the available variables would best represent the characteristics. In some cases, a mapping from the primary data to the characteristics was evident, for example, the datasets included variables for pipeline materials and pipeline age (year). In other cases, the team identified proxy variables to represent the characteristic, for example, customer counts were proxied by the "Services" field, which is described in the data documentation as "Number of services—Services typically serve one customer each." In some cases, multiple fields were combined to create a new variable to represent a characteristic, for example, "Customer per Mile" is derived by dividing "Services (count)" by the sum of "Medium Pressure Mains (miles)" and "Medium Pressure Services (miles)" to provide a measure of the number of customers served by a mile of gas distribution system pipeline.

In the case of the pipeline replacement cost, identifying representative variables was more complicated. The IOUs' Gas System Census Tract Data included only one cost field: "DistAvCost" defined as "Average cost per mile to replace distribution pipeline" in an operating district. The research team found that this cost field was consistently populated only in PG&E's dataset, and therefore, an imputation method was applied to fill in missing data to represent

this key variable for SoCalGas, SDG&E, and SWG. See the text below for a complete mapping of gas assets sub-indices to variables, with the variables grouped by the characteristics they represent.

Variable Imputation and Derivation

Most variables in the IOU data were included directly, without transformation, in the model to construct the sub-indices. There are several exceptions where variables were transformed in some way before being included in the model. These exceptions include:

- **Pipe Materials:** six pipe material variables were summed to create a single 'Pipe Materials' variable, which was included in the K-means value scaling model. The scaling model was used to ensure that features measured on different scales contribute equally to the iterative process of assigning observations to user defined clusters, recalculating cluster centers, and repeating these steps until the grouping stabilizes. More details are described on page 36.
- **District Average Cost (DistAvCost):** The PG&E DistAvCost field was included directly in the model, but due to data gaps, the DistAvCost field was imputed for SoCalGas, SDG&E, and SWG. Using PG&E's DistAvCost, the project team was able to impute DistAvCost for the other gas utilities using fields that were more reliably populated for all utilities. The project team utilized a regression-based approach, fitting a multivariate Ordinary Least Squares (OLS) model on known data and then used this model to predict DistAvCost for census tracts where it was missing. The final OLS model had an R^2 value of 0.924, indicating high predictive power. Additional information on the imputation is described in the Secondary and Tertiary Metrics Report listed in the "Project Deliverables" section.
- **Customers per Mile:** a variable derived for input to the Demand sub-index, as described in the preceding section, to represent the number of customers served by a mile of gas distribution system pipeline.

Data Resources and Sub-Index Detail

The sub-indices, characteristics, variables, and variable descriptions for the Gas Asset Index are shown in Table 3. All data were sourced from R.20-01-007, with the majority of fields described in the March 1, 2022, Gas System Data Ruling (CPUC, 2022a) and supplemental data fields described in the September 21, 2022, Revised Gas System Data Ruling (CPUC, 2022b).

Table 3: Variables to Sub-Indices for the Gas Assets Index

Sub-Indices	Characteristic	Variable Descriptions
Safety, Environment, Regulatory	Pipeline Age	• AvMainYear: Year pipeline was installed, averaged across distribution main pipeline miles • AvServiceYear: Year pipeline was installed, averaged across distribution service pipeline miles • Oldest: Miles of distribution main and service pipeline older than 1941 or with unknown installation date
Safety, Environment, Regulatory	Pipe Materials	• EarlyAldylA: Miles of distribution main and service pipeline made of Aldyl-A plastic installed in 1965-1972 • LaterAldylA: Miles of distribution main and service pipeline made of Aldyl-A plastic installed in 1973-1985 • UnkDateAldylA: Miles of distribution main and service pipeline made of Aldyl-A plastic with unknown manufacturer or installation year • NCPSteel: Miles of distribution main and service pipeline made of steel without cathodic protection • Copper: Miles of distribution service pipeline made of copper • Iron: Miles of distribution main and service pipeline made of wrought iron
Safety, Environment	Pipeline Leaks	• AvMainLeaks: Main leaks identified in leak surveys, excluding repaired or removed leaks, averaged across distribution main pipeline miles • AvServiceLeaks: Service leaks identified in leak surveys, excluding repaired or removed leaks, averaged across distribution service pipeline miles • HistAvMainHazLeaks: Main hazardous leaks (grade 1) repaired in 2015-2020, averaged across distribution main pipeline miles • HistAvServiceHazLeaks: Service hazardous leaks (grade 1) repaired in 2015-2020, averaged across distribution service pipeline miles

Sub-Indices	Characteristic	Variable Descriptions
Safety, Environment	Pipeline Risk	• AvMainRiskScore: Risk score averaged across distribution main pipeline miles • AvServiceRiskScore: Risk score averaged across distribution service pipeline miles
Safety	Customer Proximity	• High consequence area (HCA): Overlaps an HCA, which is a populated area near transmission pipelines, where accidents would have higher human consequences • Moderate consequence area (MCA): Overlaps an MCA, which is moderately populated areas or four-lane road near transmission pipelines
Environment, Demand	Gas Consumption	• TotalLoad: Average annual daily gas consumption in 2021 • LoadChange: Annual gas demand change from 2015 to 2020
Cost	Pipeline Replacement Cost	• DistAvCost: Average cost per mile to replace distribution pipeline in the Division (PG&E) DistAvCost Imputed for SoCalGas, SDG&E, and SWG based on: • Diam2OrLess: Miles of distribution main and service pipeline with diameter of 2" or less • Diam2to4: Miles of distribution main and service pipeline with diameter over 2" through 4" • Diam8to12: Miles of distribution main and service pipeline with diameter over 8" through 12" • DiamOver12: Miles of distribution main and service pipeline with diameter over 12" • DiamUnk: Miles of main or service distribution pipeline with unknown diameter • AvMainPressure: Set pressure, averaged across distribution main pipeline miles • AvMainConsq: Calculated probability of serious safety incident given leak, or consequence of failure, averaged across distribution main pipeline miles • MainValves: Number of valves on distribution main pipelines. Portions of the system can be isolated by closing two or more valves.

Sub-Indices	Characteristic	Variable Descriptions
Demand	Customer Count	• Services: Number of services—Services typically serve one customer each—used as a proxy for customer count
Demand	Large Customers	• LargeCustomers: Number of large volume customers (count of customers that can receive more than 40,000 cubic feet/hour of gas)
Demand	Customers per Mile	• Services: Number of services—Services typically serve one customer each—used as a proxy for customer count • MedPressMains: Miles of medium-pressure (60 psi or below) distribution main pipeline • MedPressServices: Miles of medium-pressure (60 psi or below) distribution service pipeline

Source: Mindful Gas Decommissioning Research Team

Non-Residential Decommissioning Readiness Index

The Non-Residential Decommissioning Readiness Index is intended to represent the technical feasibility of non-residential customers disconnecting from gas service based upon the current volume of their gas consumption and the availability of alternative fuel technologies for different end-uses of gas.

Fundamentally, the non-residential decommissioning readiness index seeks to quantify:

- The relative difficulty of substituting specific gas end-use activities with alternative fuels based upon the availability and cost-competitiveness of existing technologies
- The concentration and total volume of gas use among non-residential customers by commercial or industrial sub-sector and corresponding end-use energy service category

Data Representation and Metrics

Decommissioning non-residential distribution gas customers presents significant challenges, given the limited availability of commercially viable electric appliances and equipment capable of replacing all existing gas end uses across the commercial and industrial sectors. At the present time, the majority of existing commercially available fuel substitution appliance and equipment offerings are based on electricity. However, in the future, other similarly technically and economically viable solutions based on alternative energy carriers may emerge.

The approach to developing this index involved the following key steps:

- Quantify the proportions of total gas non-residential distribution consumption being used to provide different end-use services/activities.
- Quantify the relative difficulty or ease with which it would be currently possible to replace existing end-use gas equipment with non-gas-powered alternatives.

Methodology and Rationale

The approach to calculating gas use involved the use of a large private database of non-residential customer account-level metered gas consumption for the State's major investor-owned gas service providers. This database includes billing interval records from the year 2021 for all customers in PG&E, SoCalGas, and SDG&E service territories (PG&E, SoCalGas, & SDG&E 2021). Unfortunately, data for the SWG service territory was not available at this time but could be incorporated into future iterations of the analysis if it becomes available. To protect non-residential IOU customer privacy, no sensitive customer information or usage data are exposed within the tool in the form of published raw variable inputs. These data were only used in the background calculations that were performed to construct the unitless scores for each of the various non-residential decommissioning readiness sub-indices.

As a starting point in this process, each non-residential customer in this database was identified with a six-digit code from the North American Industrial Classification System (NAICS). The NAICS is a nested classification scheme, which provides detailed information about the nature of business or production activities occurring at each customer premise. Furthermore, these NAICS codes can be used to link customer usage records to external published end-use consumption survey results which report the relative proportion of gas consumption for different categories of end-use activity by NAICS sector.

To calculate the relative difficulty or ease of replacing gas equipment, the research team developed a relative weighting scheme to assign more importance to gas consumption powering end-use categories deemed more difficult to substitute using non-gas-powered technologies. This weighting scheme works by multiplying the raw NAICS code level aggregated consumption data for each end use by a multiplier coefficient reflecting the relative difficulty of gas substitution in that category.

Three coefficients were used in this scheme to reflect the team's qualitative assessment of meaningful differences in the overall technical and economic readiness of available gas-substitution technology alternatives by end-use category:

- Low Readiness = 3
- Medium Readiness = 2
- High Readiness = 1

The precise mapping of weighting coefficients to end-use categories within different sectors is described below.

Within this framework, consumption records for groups of NAICS codes that shared end-use gas consumption breakdowns were aggregated prior to performing the weighting calculation. These collections of customers map to sectors that constitute the major component sub-indices of the final composite gas decommissioning readiness, which is currently presented in the tool. The major quantitative steps involved in generating each non-residential decommissioning readiness sub-index are summarized in Figure 7 and described in more detail below.

Figure 7: Non-Residential Decommissioning Readiness Workflow



Summary of the major quantitative steps used to generate each Non-Residential Decommissioning Readiness sub-index.

Source: Mindful Gas Decommissioning Research Team

For each unique NAICS code which appears in the dataset for non-residential customer accounts, the research team assigned a higher-level sectoral designation that links to published data about the breakdown of gas consumption by end-use category. These approximately map to the first three digits of the NAICS codes.

Aggregated tables of non-residential customer usage were computed for each census tract and sector. Decommissioning readiness weighting coefficients were then assigned for a set of end-use categories specific to each sector. Weights range from 1-3 (High, Medium, Low). These end-use categories corresponded with those variously identified in the CEC's Commercial End-Use Survey (CEUS), NREL's county-level industrial energy use database, and the US EIA's Manufacturing Energy Consumption Survey (MECS).

Raw decommissioning readiness scores were then computed for each census tract. This was done by computing the scalar product of a vector representing total aggregated gas usage for each sub-sector and another vector representing the fractional breakdowns of gas consumption by end-use category within that sub-sector. This latter vector was further transformed by applying a set of weights that reflect the team's assessment of the relative technical difficulty of substituting gas for each gas end-use within that particular sub-sector. The net result of this calculation is a set of unitless values (raw scores) which are higher in locations where there are more facilities, consuming larger volumes of gas, within sub-sectors that are known to more heavily use engaged gas for end-use activities that are more difficult to substitute.

These raw scores were then binned using a univariate k-means clustering algorithm (Fisher-Jenks Clustering) and reported as ordinal values with a range of 1-10, reflecting low to high decommissioning readiness.

Weighting Coefficients

This section contains a high-level description of the weighting scheme used to quantify the decommissioning readiness of different non-residential customer sectors (commercial and manufacturing) as well as a summary of the weights chosen. APPENDIX C:

Weighting Coefficients – Detailed Tables provides detailed information for the end-use category-based weighting scheme that was developed to quantify the decommissioning readiness of different non-residential customer sectors. In the tables, the numerical weights that were applied to the consumption within each end-use category are shown along with a narrative justification for why that weight was selected and links to supporting resources.

Overview. To assess various non-residential customer sectors’ readiness to transition away from natural gas, a weighting system was developed based on end-use categories. Each category was assigned a weight from 1 to 3, where:

- 1 indicates high readiness for transitioning to electric energy
- 2 indicates moderate readiness with some barriers
- 3 indicates low readiness due to technological or market limitations

The weights assignments were supported by publicly available data and studies that provide insight into the availability of electric alternatives, cost considerations, industry norms, and policy incentives.⁴ This weighting scheme helps identify which sectors and end uses may be comparatively more or less prepared for electric technologies and where additional policy support or innovation may be needed. It provides an initial, high-level view of potential opportunities and constraints across different applications, without drawing conclusions about the full feasibility or timing of transitions in commercial and industrial applications.

In **Commercial Sectors**, most end-use categories received a weight of 1, reflecting strong readiness for transitioning to electric energy:

- **Space Heating & Cooling and Water Heating** are highly electrifiable, with technologies like heat pumps widely available and currently supported by incentives, thus assigned a 1.
- **Miscellaneous Uses** also received a weight of 1, as most equipment is already electric or has viable alternatives.
- **Cooking and Process Uses** received a weight of 2, due to entrenched industry preferences for gas and higher costs of electric alternatives, despite their availability.

The Manufacturing, Industrial, and Mining Sector presents a more varied landscape:

- Categories like **Facility HVAC, Machine Drive, Onsite Transportation, and Other Facility Support** were assigned a weight of 1, indicating that electric alternatives are widely adopted or in general easily implementable.

⁴ Supporting documents include: *California Public Utilities Commission*. Order Instituting Rulemaking to Establish Policies, Processes, and Rules to Ensure Safe and Reliable Gas Systems in California and Perform Long-Term Gas System Planning, R.20-01-007 (Oct. 14, 2021); as well as *California Public Utilities Commission*. Amended Scoping Memo, Order Instituting Rulemaking to Establish Policies, Processes, and Rules to Ensure Safe and Reliable Gas Systems in California and Perform Long-Term Gas System Planning R. 20-01-007 (Jan. 5, 2022). Additional references can also be found in the references of this report.

- **CHP & Cogeneration** and **Conventional Boiler Use** received a 2, reflecting moderate readiness. While alternatives exist, they often require significant infrastructure changes or face cost barriers.
- **Other Process Use, Process Heating, and Electro-Chemical Processes** were given a weight of 3, due to limited technological maturity and the need for further development—especially in high-energy applications and hydrogen-based systems.

Data Resources and Sub-Index Detail

The sub-indices and variables for the Non-Residential Decommissioning Readiness Index are shown in Table 4.

Table 4: Sub-Indices and Variables for the Non-Residential Readiness Decommissioning Index

Sub-Index	Variables	Data Source
• Nondurable Goods Manufacturing • Durable Goods Manufacturing • Colleges • Food Stores • Healthcare • Hotels • Miscellaneous • Offices • Warehouses • Refrigerated Warehouses • Restaurants • Retail • Schools	• Facility Level Gas Consumption • Sub-sectoral Level End-Use Gas Consumption Breakdowns • End-Use Specific Fuel-Substitution Difficulty Weighting Coefficients	• CPUC Disaggregated IOU Customer Gas Demand Database (UCLA Private Access, 2021 vintage data) • CEC Commercial End-Use Survey (2019 vintage data) • U.S. EIA Manufacturing Energy Consumption Survey (2022 vintage data) • NREL US County Level Industrial Energy Use Database (2014 vintage data)

Source: Mindful Gas Decommissioning Research Team

Residential Decommissioning Readiness Index

Data Representation and Metrics

The Residential Decommissioning Readiness Index represents the relative technical feasibility of groups of residential customers to be able to disconnect from gas service. The index's various sub-components are based on a collection of variables known to be correlated with barriers to the adoption of gas substitute technologies (primarily electric), including the integration of those technologies into the electrical and mechanical systems of existing buildings.

Fundamentally, the Residential Gas Decommissioning Index seeks to quantify:

- The relative dependence of residential customers on gas as a primary fuel source as well as metrics related to the intensity and overall magnitude of total site energy use (gas + electricity).
- Socio-economic factors that are likely to affect a household's capacity to independently support the financial and logistical burdens associated with purchasing and installing gas substitute technologies.
- Constraints related to the age and physical condition of the existing residential building stock are likely to exacerbate challenges related to integrating gas substitute technologies.

Methodology and Rationale

When it comes to the potential for residential gas customers to participate in a gas distribution system decommissioning project, the research team expects that the primary barriers will be different from those facing non-residential customers, as there are already a wide range of commercially available alternative fuel end-use equipment that can immediately be used as substitutes for all existing residential gas end-uses.

The majority of these existing residential gas-substitute equipment offerings use electricity as an energy carrier. In many cases, this is because modern heat pump technologies are ideally suited to efficiently deliver the relatively modest temperatures and pressures required for domestic end-use energy services. Given the current market landscape, a key focus of the methodology applied in this research for assessing residential decommissioning readiness was identifying barriers to transitioning residential end-uses to electric energy systems, as previously documented by this project team and other studies as referenced in the References List. For example, Gridworks (2019) and the UCLA brief (Fournier, et al., 2025) emphasize financial and equity obstacles for low-income households, while analyses by E3 (Aas, et al., 2020, Gold-Parker, et al., 2024) highlight structural and policy issues such as the “obligation to serve” and need for all-customer participation in gas shut-offs. The National Academies of Sciences (2021) broadly confirms that economic, political, and social factors—rather than technology—now constitute the chief barriers to building electrification. Each of these studies reinforces that overcoming these barriers will require targeted policies (for example, incentives, protections for renters, grid planning) and robust community engagement to ensure an equitable transition away from residential gas use.

Some of the barriers highlighted in these studies include:

- High upfront costs
- Split incentives for renters
- Aging housing stock
- Remaining gas customers’ burden
- Policy/planning gaps
- Data and awareness gaps
- Lack of long-term planning

- 100 percent “opt-in” participation required to retire a gas main
- Community acceptance and awareness
- Competing priorities in low-income areas

The approach to the development of the Residential Decommissioning Readiness Index involved the creation of three sub-indices. Each of these reflects a separate set of challenges or considerations that are distinct from the technological maturity of gas-substitute appliance or equipment offerings. These sub-indices include relevant information about:

- The physical condition of the residential housing stock within each census tract as pertains to the needs of electric appliance integration
- The degree to which residential households may or may not have the financial resources necessary to support the early retirement of existing installed gas appliances and their replacement with new substitute equipment
- The degree to which residential customers are currently dependent upon gas for the provisioning of the full suite of end-use energy services that they consume

The underlying variables that have been assembled to create the three residential gas decommissioning sub-indices are drawn from a combination of public and private sources. The main source of public data is the 2022 American Community Survey (ACS) 5-Year estimates census tract attributes related to housing tenure and costs, as well as the physical condition of the residential housing stock and certain classes of installed end-use energy equipment.

Census data were accessed programmatically via a Python application programmatic interfaces (API). A coded list of all the ACS attribute fields used in the analysis is provided in the relevant section below. Alternatively, the main source of private data is a large historical database of account-level electricity and natural gas consumption, obtained from California's four major IOU service providers (PG&E, SDG&E, SCE, and SoCalGas) through a data-sharing agreement established between the UCLA team at CCSC and the CPUC's Energy Division for purposes of another project. In accordance with CPUC mandated customer usage data anonymization and aggregation guidelines, all uses of residential IOU customer usage data involved aggregations containing a minimum of 100 residential customers. In instances where this threshold could not be achieved for a given census tract, usage related attribute values were treated as NULL and then inferred based upon a geographic proximity-based imputation method which operate using the remaining available data.

In this analysis, account-level consumption data for the 2020 calendar year were used. Account addresses were geocoded to the parcel level and linked to parcel-level building attribute information compiled by county tax assessor offices. These annualized consumption data were then normalized using different parcel attributes to derive needed fields. These fields were ultimately used as inputs to the Household Gas Dependence sub-index as described in the following.

Data Resources and Sub-Index Detail

The sub-indices and variables for the Residential Decommissioning Readiness Index are shown in Table 5.

Table 5: Variables to Sub-Indices for the Residential Readiness Decommissioning Index

Sub-Index	Variable	Data Source
Housing Stock Condition	• Percentage of total housing units that are in 4+ unit MF buildings • Percentage of total housing units that were built prior to 1978 • Median home value	ACS 5-Year 2018-2022
Household Financial Stability	• Median household income • Percentage renter housing units • Median gross rent as a percentage of household income • Homeowners with mortgage housing costs that are greater than 50% of their household income • Homeowners without mortgage housing costs that are greater than 50% of their household income • Renter housing costs greater than 50% of their household income	ACS 5-Year 2018-2022

Sub-Index	Variable	Data Source
Household Gas Dependence	Percent of total housing units with gas heating equipment	ACS 5-Year 2018-2022
	- Single Family (SF) & Multi-Family (MF) residential parcel median annual gas consumption as a percentage of total site energy use - SF & MF residential parcel median annual gas consumption in therms - SF & MF residential parcel median annual gas consumption per square foot of built area - SF & MF residential parcel median annual electricity consumption in kilowatt-hours (kWh) - SF & MF residential parcel median annual electricity consumption per square foot of built area - SF & MF residential total annual electricity consumption in kWh - SF & MF residential total annual gas consumption in therms	CPUC Data / anonymized, aggregated, and imputed

Source: Mindful Gas Decommissioning Research Team

Combined Indices

The purpose of the combined index is to effectively aggregate the four indices to provide an overall assessment of gas decommissioning risks, costs, and benefits. The “Combined Index” layer provided by default within the tool was computed as an evenly weighted summation of the four Index layers and then renormalized to a 1-10 value range using the same k-means optimization algorithm used elsewhere throughout the analysis. Figure 8 provides a graphical illustration of how the four index layers within the tool are additively combined to create this combined index.

Figure 8: How Different Index Layers are Additively Combined to Create a Combined Index Layer Within the Tool

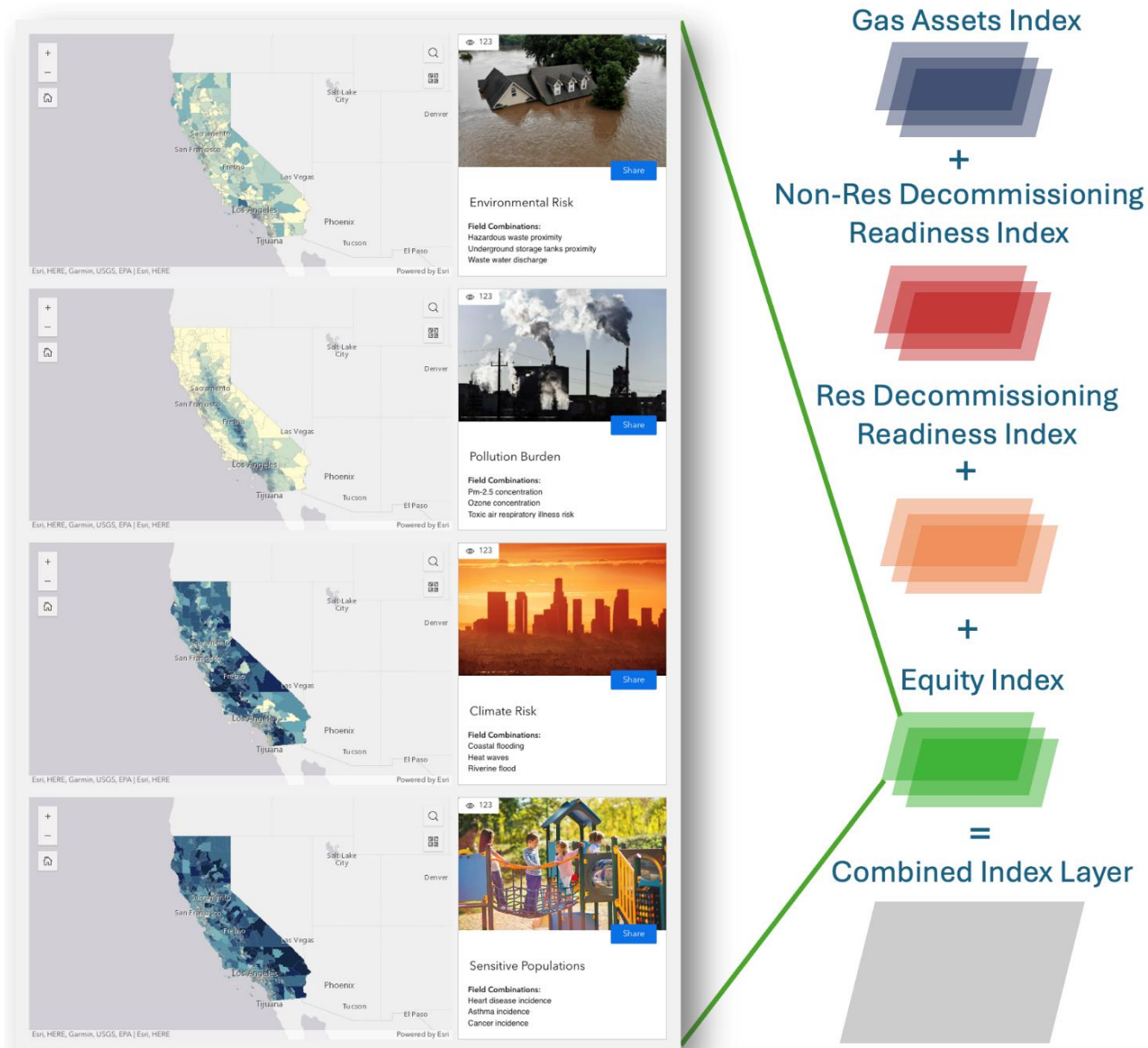


Illustration of how the four index layers in the tool are combined to create the overall “Combined Index.” The Combined Index is designed to aggregate the four component indices to provide an integrated assessment of gas decommissioning risks, costs, and benefits.

Source: Mindful Gas Decommissioning Research Team with Screenshots from the Gas Distribution System Decommissioning Screening Tool

The default approach to performing this combination involves the application of a uniform weight to each index layer. The GIS-MCDA framework also allows stakeholders to assign different weights to sub-indices to better reflect individual or community perspectives on their relative importance. Weighting is discussed in more detail below. More details about the implementation of this solution are provided in the Data Driven Tool Report, one of the project deliverables listed at the end of this report.

The combined index layer was designed to be useful for developing an overall sense of which locations are the most comprehensively suitable for the desired application when simultaneously considering multiple, potentially competing, issues of concern. The team considers this to be particularly useful when none of the individual criteria involved with the screening for promising sites decision can be allowed to strictly dominate any or all other criteria. Having a single layer that provides a comprehensive overview can also be useful as an initial point of entry for stakeholders who may be familiar with some but not all the criteria of concern. These types of site-selection/screening problems draw upon large numbers of heterogeneous prioritization criteria and their associated primary data sets. Additionally, navigating the combined index layer, as a first experience with the tool, can provide a useful initial introduction to the way in which a problem has been framed and to the various data sources that were drawn together to support this framing.

Methods of Estimation

Value Scaling

Input data needs to be standardized to align observations of varying units and scales. Several options for value standardization include min-max scaling, standard error scaling, and ranking/binning. For this project, a ranking/binning approach with 10 bins was used to discretize the decision index while retaining sufficient information about the variance and underlying distributions of the input variables. The indices were calculated using a tiered approach, aggregating from primary variables up to the final composite index in stages. The k-means and Jenks Optimization methods were used for the binning procedure.

Fisher-Jenks Optimization. This method seeks to minimize the variance within a set of defined classes while maximizing the variance between them. It involves selecting the attribute to be classified, generating initial class boundaries, computing mean values for each class, and adjusting class boundaries to reduce the total sum of squared deviations. The process iterates until the within-class variance is minimized and between-class variance is maximized.

K-means Clustering. K-means is an unsupervised clustering algorithm that assigns observations into k classes, where k is chosen by the user. The algorithm involves choosing k cluster centers, assigning observations to the closest cluster center, recalculating the cluster centers, and repeating the process until convergence or until the within-cluster sum of squares falls below a threshold.

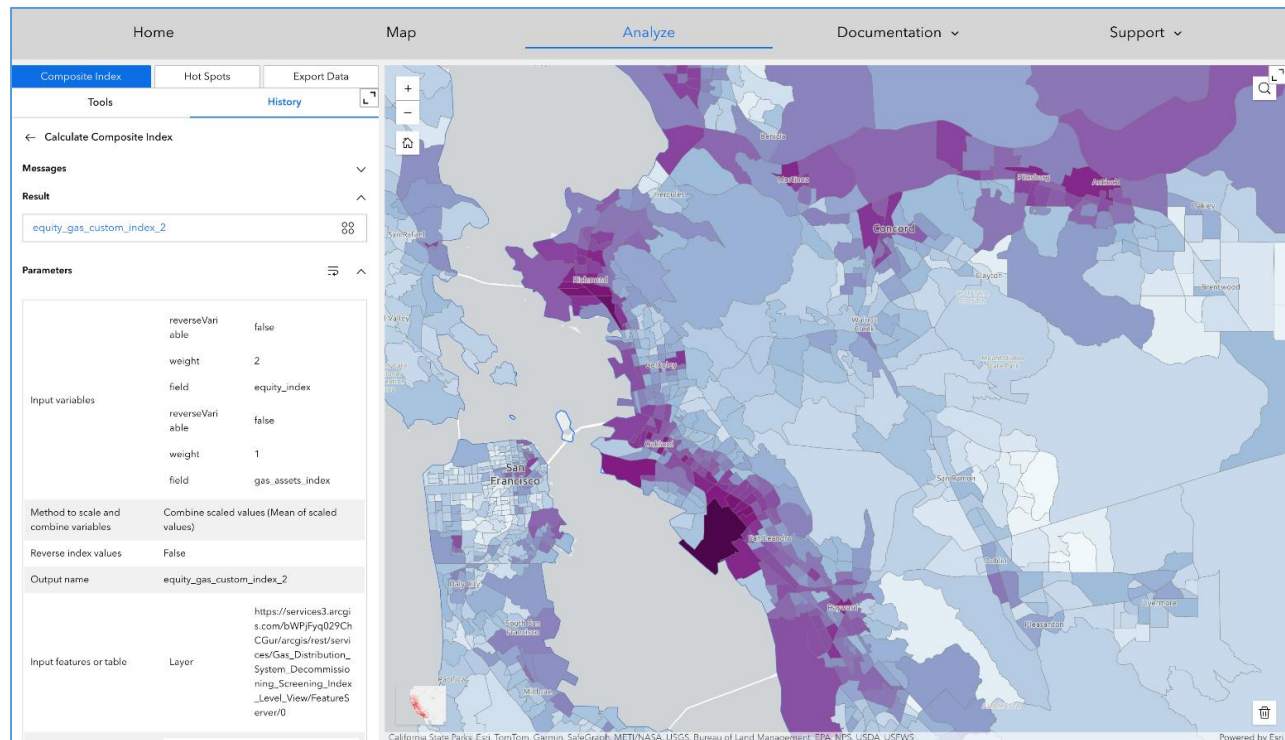
Criteria Weighting

The default composite index layer presented in the tool (Figure 9) is based on a simple uniform weighting scheme. The tool is designed to facilitate the dynamic application of user-defined weights at both the index and sub-index levels, allowing users to evaluate any possible combination of weights. This functionality was developed based on feedback from communities and other interested parties.

In line with the scope of this study, no additional evaluations of the outcomes associated with the application of different weighting schemes were performed—except for the pre-existing weighting used in the Energy Burden sub-index and Climate Risk sub-index. Based on input

from stakeholders and community partners, pre-computed outputs based upon different weighting combinations were not pre-built into the tool. Instead, users can apply custom weights to sub-indices and indices in the Analyze tab of the tool. This allows weighting to reflect specific policy objectives and community needs, which may vary by region or IOU service territory.

Figure 9: Screenshot of the Tool’s “Analyze” Page Demonstrating the Process of Creating a Custom Index based on User Specified Criteria Weights



Default composite index layer generated using a uniform weighting scheme. The tool enables users to dynamically apply custom weights at both the index and sub-index levels—reflecting policy priorities and community-specific needs—based on feedback from communities and other stakeholders.

Source: Screenshot from the Gas Distribution System Decommissioning Screening Tool – Analyze module

Imputation

Imputation refers to inferring values for a given attribute or data field when data is missing. Commonly used imputation methods include filling missing values with the median or mean. More tailored approaches that retain more information about the underlying distribution of the data, such as multivariate linear regression, can be used when there is additional information available to support them. Different imputation methods, including regression-based methods, were applied for this research to infer missing values for different attributes, leveraging unique structural characteristics of each attribute to improve the quality of inference, meaning they enhanced the accuracy, reliability, and contextual relevance of the estimated values. This is particularly important because high-quality imputation ensures that subsequent analyses, such as index development and geospatial modeling, are based on data that more closely reflect real-world conditions. In turn, this leads to more robust and defensible decision-making

outcomes, which are critical when screening for priority areas for natural gas decommissioning and assessing community impacts.

Tool Development and Refinement

Tool Platform Planning and Design

The project team engaged with CEC to determine the ideal representation of the tool and created a geospatial “mapping” tool where geographical regions of interest are color-coded and highlighted through overlays/layers and filters. The initial “beta” version of the tool was developed under UCLA’s Enterprise ArcGIS Site License. The “final” version of the tool was re-created under the CEC’s Enterprise ArcGIS Site License.

In the first year of the project, the team developed a mock-up framework of the tool. In response to CEC staff feedback, the team refined this into a demonstration tool by the 15-month period of the project. In the final year of the project, the team worked closely with CEC staff to refine the interface, ensure that appropriate metrics were presented and addressed, and develop documentation to allow state agency staff to use and manage the tool. While the tool is not currently available for public use, there may also be a need to train future developers and users in the use of the tool. The team also provided data sets necessary for the analysis and addressed appropriate data protections and confidentiality concerns through application of industry best practice for data management.⁵

Choice of Hosting Platform for the Tool

The project team considered various technical solutions for making the desired features of the tool accessible through an interactive web-based interface. As the data involved are inherently geospatial and many of the anticipated modes of user interaction would involve spatial lookups and contextual assessments, the team decided to focus on GIS-specific data hosting and web-development platforms. Among the GIS-specific tools that exist, by far the largest and most feature-complete is the Environmental Systems Research Institute’s (ESRI) ArcGIS product suite. The CEC, CPUC and all the State’s IOUs have organizational level licenses to ESRI’s ArcGIS Online (AGOL) products. This means that these organizations already have robust capabilities to support the development, maintenance, and controlled use of sophisticated interactive web-GIS applications using AGOL based services. Indeed, many of the State’s existing open data portals and energy infrastructure analysis tools are already implemented using AGOL. Moreover, DNV and UCLA were already members of licensed AGOL organizations. For these reasons, AGOL was the natural choice of development platform.

ESRI ArcGIS Experience Builder

Within the ESRI ecosystem there are various options for developing interactive web-GIS applications. These options range from completely pre-configured “instant applications” to fully customizable enterprise grade solutions that require developing custom software using ESRI’s various APIs and software development kits. Positioned between these two extremes are other options that can provide a useful balance between user customizability and development /

⁵ [White paper](https://www.esri.com/content/dam/esrisites/en-us/media/technical-papers/content-management-techniques-for-your-arcgis-enterprise-portal.pdf) that describes the types of content management strategies that were employed in developing the Tool: <https://www.esri.com/content/dam/esrisites/en-us/media/technical-papers/content-management-techniques-for-your-arcgis-enterprise-portal.pdf>

deployment velocity. One of these is the ArcGIS Experience Builder, which is a powerful and highly configurable web application development platform that allows users to create interactive web experiences without the need to write code.

The project team selected ArcGIS Experience Builder as the development platform for this project for several reasons. The first is that it is designed to bring together web maps, apps, pages, interconnected widgets, and both 2D and 3D data into a single, cohesive interface. Second, the Experience Builder platform allows for the development of interactive web-applications, with rich geospatial content, using a no-code, “what-you-see-is-what-you-get” (WYSIWYG) editor. This editor environment makes it possible to add and arrange various components like maps, images, text, buttons, and other interactive widgets using an intuitive graphical user interface. This type of development workflow significantly increases the speed with which different ideas can be prototyped and iterated upon. It also makes the task of maintaining the tool significantly easier for its long-term owner.

Some additional benefits of the Experience Builder platform include a wide range of predefined templates that can be used as starting points. These templates are highly customizable in terms of colors, fonts, layouts, and design elements. Also, applications developed using Experience Builder are natively responsive. This means that they automatically adapt to different screen sizes (desktops, tablets, and mobile devices), ensuring a consistent and user-friendly experience across all devices. Custom layouts can also be configured for each device type and there is also the possibility of building custom widgets, themes, and actions using modern web technologies like React and TypeScript.

Experience Builder applications are primarily intended to connect to datasets which are hosted on the ArcGIS Online platform. By linking to such interactive datasets, which are accessible via native Representational State Transfer API’s, widgets in Experience Builder can interact with each other, data, and content, facilitating custom workflows and even data-driven applications. These applications can be designed to function either as a single page or with multiple different pages and views, similar to a typical website.

AGOL Organizational Partnerships and Group Sharing

Experience Builder applications that are owned by an organizational user account can be published and shared with specific audiences affiliated with one or more different ArcGIS organizations or they can be made available publicly, without restriction. Restricted access to an Experience Builder application can be achieved by inviting individual users to participate in a user group with the requisite access permissions. However, this process requires that all these users be either a member of the same organization that the application owner belongs to, or another organization with whom they are partnered. Organizational level partnerships can be established by mutual agreement between a respective set of AGOL account administrators.

Under this group sharing model, the CEC will have significant flexibility in determining which specific individuals representing state agencies, utilities, or other stakeholder groups will have access to the tool and its associated data resources. Additionally, using the “Add Data” features contained within the tool, CEC and CPUC staff could incorporate external sources of

information (even confidential customer usage and gas infrastructure data) maintained by the state's IOUs, so long as the information is accessible through the AGOL platform.

Scalability of Hosted Datasets and User Access

Due to AGOL's use of distributed database technologies and high-performance computing and networking hardware, there are few technical constraints on the potential scale of either the size of the datasets hosted within the tool or the number of potential users that it could support. Thus, long-term, it is possible that this same tool could be used to visualize and analyze asset level information for the entire gas distribution system and its customer base, though these use cases would have to be supported by the resource allocation limits associated with the CEC and other users' AGOL site license.

Populating, Verifying, and Validating the Decision-Making Framework

The project team populated the tool by collecting and processing data from a range of sources, including IOUs, municipalities, and public datasets. Stakeholders were generally willing to provide data at various levels of resolution with the notable exception of gas service providers. A number of requests for access to confidential gas asset level data were submitted to various IOUs throughout the state, with the project team offering to receive such data under appropriate non-disclosure agreements (NDAs). Unfortunately, none of these conversations bore fruit in terms of reaching an actual data sharing agreement. Consequently, only aggregated gas asset data that was made publicly available through the CPUC's Long Term Gas Planning proceeding (CPUC, 2024) could be used. The research team was able to access other confidential data, such as historical account-level metered electricity and natural gas usage, under pre-existing NDA's—under the provision that requisite data aggregations and anonymization protocols were adhered to in the production of all derivative data products.

Where direct data sharing was not possible, proxy representations were developed to ensure the tool could reflect community and pipeline network characteristics with sufficient fidelity. Given the complexity of developing a statewide tool, the model was populated incrementally, with ongoing engagement from stakeholders, including community members, TAC members, and CEC and CPUC staff, at each stage to validate the model's findings.

Verification and validation were integral to this process. After each round of data integration and model development, the team presented and discussed the evolving framework with stakeholders. This collaborative approach enabled the team to assess the accuracy and suitability of both the data and the model's predictions. Criticisms and suggestions from stakeholders were actively incorporated, resulting in iterative refinements and a list of further recommendations. By embedding verification and validation within the process, the team ensured that the tool remained robust, credible, and responsive to stakeholder needs throughout its development.

Tool Demonstration, Documentation, and Training

The project team performed tool demonstrations to CEC and CPUC staff in months 12-15 of the project, and several demonstrations of the more final Tool were given in the final year of the project. During these demonstrations, the team accepted feedback to incorporate into revisions and helped to augment the documentation and training developed to enable effective use of the tool. On October 28, 2025, the project team led a Tool Transfer meeting with CEC

and CPUC staff to provide a detailed overview of the tool’s features and applications as well as a discussion about how to update and extract data.

Community Engagement, Case Studies, and Resource Hub

Community Engagement and Feedback

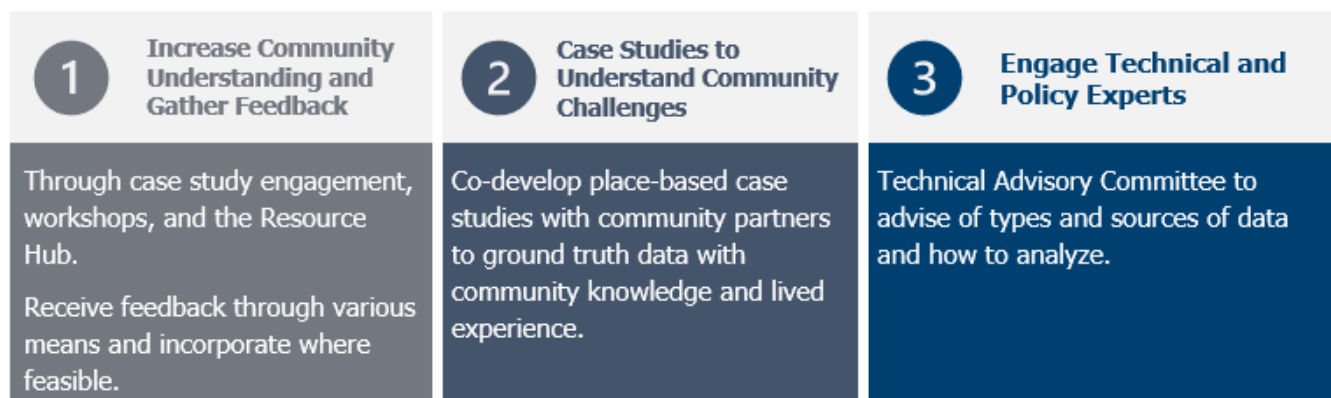
Given the nascency and complexity of gas decommissioning, the research team developed a detailed methodology for building the tool. To inform this approach, the team implemented a multi-layered statewide outreach effort that engaged state agencies, IOUs, municipalities, community-based organizations, and other stakeholders involved in energy, housing, and environmental decision-making (see APPENDIX Attendee Lists). In addition, the team partnered with local organizations in diverse communities across the State—including tribal, rural, urban, industrial, and agricultural areas—to co-develop case studies that provided contextual insights into local conditions and considerations relevant to decommissioning. While this engagement was not intended to represent comprehensive or uniform “community priorities,” it provided grounded, place-based perspectives that helped shape the tool’s design and ensure that its analytical framework remained connected to real-world contexts faced by communities across different parts of California.

The project’s TAC also worked with the project team to ground the tool’s development in both technical rigor and stakeholder relevance. Convened early in the process, the TAC provided structured feedback through targeted meetings, presentations, and surveys, helping shape decisions on data selection, methodology, and analytical design. Their guidance ensured that the tool’s framework remained scientifically robust while responsive to the practical needs of regulators, utilities, and community partners.

This inclusive approach helped validate data, elevate critical factors, fill in gaps, and incorporate diverse perspectives on the costs, risks, benefits, and community impacts represented in the tool. This approach balanced both project and community capabilities and resources. Its goal was to support a data collection and analysis effort that best informed the development of the tool. The pathways for community engagement and input that informed the tool development are detailed below.

A key objective of the tool is to equitably prioritize candidate locations for potential decommissioning throughout the state. To accomplish this, the types of data and metrics collected needed to be validated at various community-represented levels and forums, including workshops and a public webinar, but in particular through case-study meetings with community partners. Other forums included direct community engagement (for example, briefings with affinity groups), through an online Resource Hub (see description below), and through the TAC, where feasible. See Figure 10 for a summary of the research team’s community engagement and feedback process.

Figure 10: Community Engagement and Feedback Process



Summary of the research team’s community engagement and feedback process used to validate the data and metrics informing the tool. A core objective of the tool is to equitably prioritize candidate pipeline segments or locations for decommissioning across the state, which required extensive input from community-represented groups.

Source: Mindful Gas Decommissioning Research Team

Community Workshops and Webinar

The research team led two community workshops to introduce the research and its objectives, as well as a final webinar demonstrating the tool in its conceptual and beta stages.

Hosted in October of 2023, Workshop One served as the project’s initial touchpoint with a broad range of stakeholders. This workshop provided a foundation for introducing the project scope, gathering early insights, and validating preliminary ideas for the tool’s equity and technical metrics and helped ensure that the tool’s design reflected community priorities from the outset. Participants self-selected into four facilitated discussion groups—an informational session on gas decommissioning, a conversation on community impacts and equity metrics, a technical discussion on developing a data-driven tool, and a Spanish-language discussion covering all three topics. These small-group dialogues allowed community-based organizations, advocates, utilities, and local leaders to reflect on the potential impacts of decommissioning, identify community priorities, and offer early guidance on the tool’s emerging framework.

Feedback from the workshop directly shaped the tool’s early development. Participants highlighted concerns related to coordination challenges and unintended impacts of decommissioning identified socioeconomic vulnerability, climate risk, sensitive populations, pollution burden, and energy burden as top equity priorities, and emphasized cost and safety as the most urgent gas asset considerations. The workshop underscored the need for clear communication, localized data, and inclusive planning processes to foster equitable outcomes.

Hosted in October of 2024, Workshop Two focused on demonstrating how community and stakeholder feedback had directly shaped the evolving tool. Results from the workshop helped strengthen the tool’s credibility and demonstrated the importance of grounding technical assessments in lived experience. Using a live demonstration of the Oxnard case study, participants engaged in an interactive exercise that invited them to react to tool outputs and respond to targeted research questions. As a longtime advocate for environmental justice in

Ventura County, local partner, CFROG, provided an essential community perspective during the project's early engagement phases. Their participation in the workshop helped ensure that the tool reflected the realities faced by communities living near aging gas infrastructure. By co-presenting with the project team, CFROG shared on-the-ground insights from Oxnard residents and illustrated how local experience can sharpen the relevance and equity of decommissioning decisions.

This workshop created space for both shared priorities and place-specific concerns to emerge, illustrating the value of combining community insight with technical screening methods. Participant feedback from the workshop highlighted several themes that informed refinements to the tool and future engagement strategies. Attendees emphasized the importance of infrastructure removal for public safety, proper handling of residual gases and contaminated materials, and transparent, inclusive communication to prevent disproportionate impacts in vulnerable communities. They also identified opportunities of decommissioning gas assets, such as reduced fossil fuel reliance and improved air quality, while raising concerns about financial burdens and inequitable transition processes. The workshop was also used to report back on how earlier input had been incorporated and to gather additional reactions to the Oxnard case study.

DNV and UCLA also hosted a public webinar in October 2025 to highlight the innovative development of the tool and its role in supporting equitable gas decommissioning across California. The event provided a live demonstration of the final version of the tool, including an in-depth co-presentation of the Visalia case study location in partnership with Self Help Enterprises (SHE), to illustrate how local insights and lived experience can inform statewide strategies. As a trusted organization with deep roots in California's rural and underserved communities, SHE played a critical role in ensuring that the tool reflected the lived experiences and priorities of residents most impacted by gas infrastructure transitions. By presenting alongside the project team, SHE offered a community-based perspective on how the tool performed in practice and why local knowledge is essential for equitable decommissioning planning.

To connect research findings to gas planning and transition policy, the October 2025 webinar emphasized the importance of centering community needs, surfacing trade-offs, and fostering transparent, accountable decision-making. The session also invited feedback from community partners, TAC members, IOUs, State agencies, ensuring that the tool's future applications are shaped by diverse voices and grounded in real-world conditions. This collaborative approach strengthens trust, builds capacity for responsive engagement, and positions the tool as a platform for ongoing dialogue and partnership in California's energy transition. See Chapter 3, "Results" and Chapter 4: "Knowledge Transfer" for detailed information about the impact of each of the workshops and the public webinar.

Case Studies

Case studies were co-developed with local partners to help validate the team's data, elevate critical factors to include in the tool, fill in knowledge/data gaps and incorporate diverse perspectives on the costs, risks, benefits and community impacts. A comprehensive list of case

study findings and a detailed case study methodology can be found in the Community Resources and Equitability Assessment Report, a deliverable provided to the CEC.

The team identified case study locations using the initial Equity Index, which was in turn shaped by the team's existing deep connections with California communities. The index provided a data-driven foundation for selecting sites that represent the diverse impacts and opportunities of gas decommissioning statewide. By prioritizing geographic diversity, the team ensured that the chosen locations reflect California's urban, rural, suburban, tribal, and regional characteristics (Northern, Central, Southern). As the project progressed, the case study selection was further refined based on the time, resource availability, and interest of community partners, resulting in a final set of case studies that, while representative, may not fully meet the original criteria for diversity due to practical constraints and partner engagement.

The research team, in collaboration with community partners, applied the tool to analyze each case study location by examining how gas asset conditions, decommissioning readiness, and equity factors intersect. This integrated analysis revealed nuanced insights into the implications of gas decommissioning and informed recommendations for future planning. For example, at the statewide level, the case studies surfaced a set of factors that could influence readiness for gas decommissioning across California—such as exposure to climate risks, gaps in available data, local grid constraints, and the importance of early and ongoing engagement with affected communities. At the local level, the case studies offered more granular insights into the specific conditions shaping readiness in each location, highlighting a number of place-based dynamics that matter to communities as the State considers potential priority siting locations. Together, the case studies illustrate a replicable approach to identify the considerations that may support or hinder implementation, as well as the challenges that decisionmakers may encounter in different contexts. Originally the research team secured commitments from 10 CBOs across California—including partners in Oxnard, North Fair Oaks, Richmond, Stockton, Sacramento, Visalia, Wilmington, Blue Lake Rancheria, San Francisco, and the La Jolla Reservation in Southern California. Due to resource limitations, several partners were ultimately unable to sustain full participation, and the team completed five fully developed case studies: Blue Lake Rancheria, Richmond, Stockton, the Central Valley, and Oxnard. For the remaining locations, the team produced partial case studies informed by available partner input—such as community connections, background data, and high-level feedback.

One of the key strengths of the tool when used in tandem with such community engagement is that its resulting scores do more than flag barriers and strengths—they reveal local complexities and indicate where deeper community engagement and analysis are needed. Ultimately, the case studies demonstrate the tool's value in practice: when used as part of an iterative screening process alongside input from community partners, it can help decision makers balance cost, safety, and readiness with equity considerations. See the "Case Studies" section in Chapter 4 for detailed results from these case studies.

Resource Hub

The Mindful Gas Decommissioning Resource Hub⁶ was developed to serve as the public-facing website to communicate the tool's purpose, methodology, and progress in a way that fosters transparency, collaboration, and accessibility for all stakeholders. To make this complex process understandable and approachable, the website provided information about the three-layer framework used in the tool: assessing the physical condition of gas assets, evaluating readiness for electric energy alternatives, and analyzing community-level impacts such as energy burden and environmental justice indicators. Through clear explanations and straightforward navigation, the site helped visitors grasp how decisions are made and why certain areas may be prioritized—empowering users to engage meaningfully with the project.

For stakeholders, including state agencies, IOUs, and community organizations, the website offered a supportive resource for tracking project milestones, understanding the data and methodology behind the tool, and engaging with the process. Throughout the project, the team used the Resource Hub to provide updates on community workshops, invitations for feedback, and encourage open dialogue and collaboration. This transparency ensured that the project remained responsive and accessible to those involved with the research.

All project materials and collateral were distributed to stakeholders, communities, and the public via the Resource Hub, with careful attention to accessibility. Materials were compliant with Section 508 for web accessibility and translated into relevant languages. To accommodate communities with technology and broadband challenges, access to the Hub was coordinated through community partners and disseminated through ongoing outreach efforts. Ultimately, the website was designed to an informational portal and a mechanism for accountability, inclusion, and shared learning.

Final Documentation and Tool Transfer

The team's strategy for transferring the tool to the CEC was designed to ensure its long-term usability, transparency, and value for policy, planning, and stakeholder engagement. The team developed a Data Product Management Plan that outlined the technical and administrative steps for transferring both the underlying geospatial dataset and the interactive web application (the tool) to CEC ownership. As described earlier, the tool itself is an AGOL web application that enables users to filter, explore, and analyze this data, with built-in documentation and guides for users. To facilitate transfer, DNV and UCLA coordinated with CEC's ArcGIS administrators to review documentation, address technical requirements, and plan the handover. This process included:

- Documenting all dataset fields and tool features to ensure future maintainers at CEC can interpret, update, and leverage the products.
- Transferring ownership of the tool within the AGOL platform to copy content between organizations.

As part of the tool handover plan, the research team shared draft and final documentation, held technical review meetings, and transferred hosting responsibilities to CEC's AGOL

⁶ <https://mindfuldecommissioning.dnv.com/> - developed to provide [public-facing information](#) regarding the tool. Maintained until the end of the project period (March 31, 2026).

organization. In October 2025, the project team led a Tool Transfer meeting with CEC and CPUC staff to provide a detailed overview of the tool’s features and applications as well as a discussion about how to update and extract data.

The team also developed a Knowledge Transfer Plan, a key project deliverable that details activities to ensure the tool and its results are shared with key stakeholder groups—including state agencies, IOUs, CBOs, and policy advocates.

This documentation and transfer process is thorough, collaborative, and designed to ensure the tool remains a valuable, transparent, and actionable resource for CEC and its partners, supporting strategic, equitable, and data-driven decisions about California’s gas infrastructure transition. See the Chapter 4, “Knowledge Transfer” for a more detailed description of the knowledge transfer plan.

Chapter 3:

Results

This section summarizes the key outcomes and insights from this project. These results demonstrate how integrating quantitative and qualitative geospatial data—and combining metrics on asset condition, readiness, and equity—can inform on conditions that could potentially balance cost, safety, and social impact. Together, the statewide analysis, community engagement and case studies illustrate how the tool supports documented community-informed screening of potential decommissioning sites in a manner that helps achieve California’s broader decarbonization and energy equity goals.

The tool supports decision-making around natural gas decommissioning by integrating multiple dimensions of analysis. Through a focus on gas assets, decommissioning readiness, and equity and community impacts, the tool makes a first attempt to integrate technical, social, and environmental data to support and guide equitable, strategic planning for gas system retirement. As such, a key outcome of this project is the tool’s ability to bridge the gap between technical complexity and community lived experience to provide a means of initial screening for priority decommissioning sites across the State. This gap often arises because quantitative and geospatial analyses operate at broad scales and rely on standardized indicators that do not always capture the finer-grained realities within neighborhoods or communities. Such metrics can smooth over local variation, overlook social dynamics, or fail to reflect how residents actually experience energy systems, housing conditions, mobility constraints, safety concerns, or local environmental stressors in their daily lives.

Because of these limitations, the tool is not a substitute for place-based engagement or deeper qualitative assessment. Instead, it offers a structured way to organize and interpret complex information while recognizing that community knowledge and local context are essential for validating and refining any subsequent decisions about decommissioning.

Figure 11 below illustrates the significant factors addressed in the tool (and which are described in Chapter 2, “Project Approach”).

Figure 11: Decision Framework for the Data-Driven Decommissioning Tool



Key factors incorporated into the tool to support equitable and strategic natural gas decommissioning decisions. By integrating data on gas assets, decommissioning readiness, and equity and community impacts, the tool provides an initial screening mechanism to identify priority sites for gas system retirement across the state.

Source: Mindful Gas Decommissioning Research Team

Research Outcomes

What makes the tool powerful is how it offers understanding of risk factors in areas that are likely more difficult to decarbonize and thus bridges the State’s decarbonization goals and local community benefits/impacts to identify pathways for implementation and equitable outcomes.

This approach directly responds to several pressing challenges currently facing state agencies and decision-makers, including translating complex and diverse data sources into actionable insights, helping visualize and understand trade-offs for decommissioning while considering stringent data security requirements and the need for robust data processing capabilities. By integrating input from subject matter experts across gas infrastructure, equity, and residential and non-residential decommissioning readiness, the tool serves to bridge gaps in expertise and coordination. Most importantly, it introduces a quantitative, analytic framework for synthesizing disparate data sets and generating summary metrics that capture the full spectrum of economic, environmental, health, safety, and equity impacts—metrics that this research showed have been largely absent from existing tools for prioritizing pipeline replacement projects (for example, from IOUs). Additionally, this research found that previous

gas infrastructure planning tools in California lacked integrated metrics and frameworks to assess the full spectrum of impacts associated with decommissioning. Notably:

Equity and community impacts: The research team sought to ensure that the tool incorporated the most comprehensive datasets available to inform the Equity Index. This approach allows for a more accurate and complete representation of the challenges facing disadvantaged and vulnerable communities, not only for consideration of direct impacts, but secondary or unintended impacts, as well as potential benefits and tradeoffs associated with decommissioning.

Data integration and visualization: Prior approaches relied on fragmented datasets and lacked a unified, visual platform for evaluating trade-offs. The tool uses a GIS- MCDA framework to synthesize technical and community geospatial data.

Scenario testing and decision support: Traditional tools did not allow for scenario modeling or comparative analysis of decommissioning strategies. This tool enables users to test scenarios and assess impacts across multiple dimensions, including health, safety, and cost.

Community engagement: The research team views and values community engagement and feedback as critical to the development of the tool that would validate its data based on community realities and not in the abstract. To achieve this level of community validation of the tool's data, the team designed and implemented a highly intentional and inclusive community and stakeholder engagement process.

These challenges must be overcome to develop a scalable and rational approach to assessing and screening for promising sites to mindfully initiate natural gas decommissioning. This research and development project was designed to meet this urgent need.

Phase One: Planning, Data Collection, and Tool Design

The project's initial research phase produced several important equity outcomes, fundamentally shaping both the tool's design and its practical application. Through a comprehensive community landscape assessment and direct engagement with a diverse array of community-serving organizations, the project team identified a number of real-world barriers and priorities that influenced engaged groups' ability to take part in the energy transition. The engagement provided the opportunity for the developed equity framework to be grounded in the lived experiences of participating under-resourced stakeholders and recognized that limited resources—not lack of interest—are some of the main obstacles to participation.

Stakeholder workshops and advisory meetings were instrumental in surfacing equity priorities. Participants consistently ranked socioeconomic vulnerability, climate risk, sensitive populations, pollution burden, energy burden, environmental risk, and access to critical services as the most important metrics for screening for potential locations for equitable, safe, and cost-effective gas decommissioning. These rankings informed the calibration of the tool's Equity Index, helping ensure that the factors affecting disadvantaged and vulnerable communities are visible and can be meaningfully considered in screening and decision-making.

The TAC played an early role in ensuring methodological rigor and stakeholder balance during tool planning and design. Convened twice during the project, the committee's expert guidance on data types, sources, and analytic approaches strengthened the tool's foundation.

The project team also responded to feedback by adding new contextual layers—such as tribal lands and building climate zones—to better reflect geographic, cultural, and climatic factors in equity analysis. Case studies and community workshops further validated the tool's metrics, revealing where modeled results aligned with local realities and where gaps remained. This iterative engagement process led to targeted updates, such as improvements to climate risk and equity metrics, making the tool more reflective of on-the-ground conditions.

Importantly, the tool's design supports transparent communication about equity scores and their implications for future decommissioning decisions. By integrating technical, social, and environmental data, the tool enables users to visualize potential tradeoffs between choosing (or weighting) sub-indices and variables, to test different weighting schemes, and to discover how to prioritize equity in both statewide and census tract-level planning. The result is a replicable, data-driven framework that advances California's goals for an equitable energy transition, ensuring that the benefits of decarbonization are shared with those most affected by energy and health inequities.

The following subsections provide a detailed account of how these outcomes were achieved, illustrating the project's approach to community landscape assessment, direct engagement, stakeholder workshops, TAC input, and the design decisions that collectively shaped the tool's equity framework and practical application.

Community Landscape Assessment and Direct Engagement

The initial landscape assessment conducted with nearly a dozen community-serving organizations offered valuable insight into the current engagement environment and the types of capacity constraints many organizations are navigating. While not intended to capture comprehensive or uniform community priorities across the state, this input helped the team understand many of the practical considerations, competing demands, and intersectional concerns—such as health, jobs, and food security—that can shape community readiness for decommissioning. These perspectives provided a grounded, contextual foundation that informed the development of the project's equity framework.

Throughout the engagement process, the team emphasized flexibility and responsiveness to partner needs, which informed how outreach activities were designed and delivered. Meeting formats, timelines, and materials were adapted to better align with partner capacity, including offering bilingual resources and implementing low-burden micro-grant processes to support participation.

Building trust was a key objective. Open communication, transparency about project goals and limitations, and a commitment to acknowledging community concerns helped create conditions for more constructive and meaningful involvement from stakeholders.

Engagement approaches were also tailored to reflect the distinct characteristics of each community and partner organization. Considerations such as cultural norms, language

preferences, and differences in technological access shaped how the team structured conversations and developed materials, contributing to an engagement process that was more inclusive and contextually grounded.

This outcome strengthened the tool's grounding in real-world community context by incorporating insights from partners who work directly with under-resourced stakeholders. At the same time, it is important to recognize that index-based scoring and geographic aggregates - such as provided by the tool - cannot fully capture the dynamics that shape lived experience (specifically, differences across individual premises, variations within a census tract, or locally specific concerns related to cost, safety, or electricity resilience). These nuances often emerge only through direct engagement, local knowledge, and on-the-ground assessment.

Accordingly, the tool is intended to provide high-level, supplemental insight rather than a definitive representation of community conditions. Its outputs can highlight locations that may warrant closer attention, but the actual considerations that influence decommissioning—such as infrastructure constraints, vulnerabilities, or community priorities—will surface through detailed planning, engagement, technical analysis, and future pilot activities. In this way, the tool serves as a starting point that supports more informed and context-sensitive decision-making, rather than substituting for real-world community understanding.

Direct Engagement, Briefings, and Technical Advisory Committee

The project's adaptive engagement strategy generated meaningful outcomes, expanding collaboration across more than 200 stakeholders—including utilities, tribal governments, regional energy networks (RENs), academic institutions, and community leaders. This broad participation enriched the tool's design by incorporating diverse regional and community perspectives, resulting in data parameters and readiness indicators that more accurately reflect California's geographic, utility, and equity contexts.

In parallel, input from the TAC enhanced the tool's technical rigor and credibility. Through targeted review sessions, TAC members helped ensure that the tool's framework aligned with regulatory standards, academic best practices, and community equity goals—strengthening its reliability for statewide application.

Impact of Workshop One

Hosted October 20, 2023, Workshop One was the first statewide introduction to the project. As such, it was a critical first touchpoint to engage with CBOs and other interested parties. The team used it as an opportunity to begin to discuss the potential impact of gas pipeline decommissioning on environmental justice and energy equity, and to gain critical feedback on both case study structure and the metrics being considered for identifying priority locations for equitable, safe, intentional and cost-effective gas decommissioning.

Workshop One established a ranked list of community and asset priorities that directly informed how the tool could be calibrated for statewide and community-level screening. Participants placed the highest priority on socioeconomic vulnerability, followed in order by climate risk, sensitive populations, pollution burden, energy burden, environmental risk, and critical services. These rankings provide an example of a stakeholder-informed framework for

weighting equity considerations in future site screening. Participants also ranked the metrics related to the Gas Assets Index in order of priority; with cost emerging as the top concern, followed closely by safety, environmental impacts, regulatory compliance, and demand. This outcome underscores the importance of integrating both economic and safety considerations alongside community equity factors in decommissioning decisions.

Following feedback from Workshop One, the project team expanded and refined the tool to better reflect the local realities and contexts presented by attendees in which gas decommissioning could occur. The team added federally recognized tribal lands and building climate zones as new contextual layers, ensuring that geographic, cultural, and climatic factors are additionally considered in future analyses.

The team also refined the structure of the case studies based on participant input. Workshop One participants emphasized the importance of selecting locations with elevated socioeconomic vulnerability and considering distinct characteristics that shape each community's experience with energy systems. This effort was focused less on directly informing the tool and more on developing a deeper understanding of local context that could illustrate the diverse considerations relevant to decommissioning communities across the state. This included incorporating distinctions among building types—such as multifamily housing, older homes in historic neighborhoods, and newer developments—as well as attending to regional climate patterns and environmental histories that influence how energy transitions are experienced on the ground.

Finally, Workshop One feedback underscored the need to address community concerns about how the tool's scores might be interpreted and what they could mean for future gas decommissioning decisions. These insights guided revisions that made the tool's case study framework more context-sensitive, and responsive to community perspectives.

Design Decisions

The tool's data design, through application of the GIS-MCDA framework, established a robust, transparent foundation for screening and prioritizing gas decommissioning opportunities statewide. The integration of feedback from technical experts, agencies, and community stakeholders led to measurable improvements in how the tool represents infrastructure realities and community conditions in the four key indices.

As described in Chapter 2, each index was designed to synthesize multiple variables into standardized, intuitive scores, allowing users to explore relationships between different indices, as well as subindex scores such as safety, cost, energy burden, and socio-economic vulnerability. This approach made the tool's output more transparent and interpretable, especially for decision-makers seeking to balance technical feasibility with equity considerations. By drawing on more than a dozen trusted public and private datasets—from CPUC rulings to CalEnviroScreen and FEMA sources—the tool reflects both the physical and social dimensions of California's energy landscape. Although the data represents the best information available at the time of development, the tool's architecture allows for future updates and refinements as new data becomes available.

Importantly, the tool serves as a first-step screening resource rather than a prescriptive siting tool. It enables stakeholders to identify promising areas for further technical and community-based analysis, visualize tradeoffs, and test different weighting schemes according to local priorities.

Through these design decisions, the tool delivers:

- Clear communication of complex technical and equity information
- An initial statewide visual overview of gas asset conditions, decommissioning readiness and equity impacts, ranked from least to most ready for decommissioning
- A scalable structure for ongoing updates and iterative improvement
- A credible, inclusive foundation for future collaboration among state agencies, utilities, and communities

Together, these outcomes have made the tool a practical and empirically-centered platform for supporting equitable, informed, and cost-effective gas decommissioning planning across California.

Beyond creating a visualization platform, the tool stands as a replicable data-driven framework for combining complex technical data with community knowledge and localized insights. Critically, this process has involved ground-truthing the tool's outputs through case studies and engagement with local stakeholders to ensure alignment with lived experience and on-the-ground conditions. This dual approach—merging quantitative data with qualitative, place-based expertise—provides essential value to the State as it moves forward with planning for an equitable and effective transition away from natural gas use. As data availability and governance continue to evolve, the framework developed here can be applied to future decommissioning modelling, ensuring that the principles of transparency, inclusivity, and contextual accuracy remain central to decision-making around gas decommissioning for the state.

Phase One: Challenges

Phase One of the tool's development surfaced several key challenges that informed both the scope and direction of future work. These obstacles highlighted the complexities of data access, stakeholder engagement, and statewide representation, each of which impacted the effectiveness and equity of the tool.

One major challenge was the limited access to asset-level gas distribution infrastructure and historical customer usage data due to a combination of privacy, security, and confidentiality concerns. These restrictions significantly constrained the tool's ability to assess site-specific conditions and opportunities relevant to specific potential gas decommissioning projects. The only gas asset data that could be obtained for use in the tool was a census aggregated snapshot of gas infrastructure conditions prepared by the IOUs in response to a data request filed by the CPUC under its Long-Term Gas Planning proceeding (CPUC, 2024). There is currently uncertainty as to whether or not such data will be updated and if so, on what cadence. Historical gas and electricity usage data (account level monthly billing interval data

for all customers within SCG, SDGE, PGE, and SCE territories) were accessed by UCLA project team members through a pre-existing data sharing agreement in place with the CPUC's Energy Division. In this instance as well, there are similarly few guarantees as to whether or not such data will continue to be available for future development of this tool. To address these limitations, future research could explore the establishment of secure data-sharing agreements with utilities and agencies, which would enhance the precision and utility of screening tools.

Another challenge involved the implementation of the TAC, which was envisioned as a critical source of expert input. However, both internal and external factors hindered their effectiveness. Internally, the team struggled to define a clear role for the TAC. In hindsight, a more structured engagement plan might have facilitated a more effective TAC. Externally, scheduling and retaining expert participation proved difficult. Future projects should ensure that advisory bodies have clearly defined roles, expectations, and timelines, and consider compensating members for their time and expertise to support sustained engagement.

Finally, achieving statewide reach and representation proved to be both necessary and ambitious. California's geographic and demographic diversity demanded significant time and resources to obtain satisfactory representation of diverse conditions across the state. To maintain quality outcomes across regions, future projects should be scoped with funding and timelines that align with the scale of the effort.

Phase Two: Tool Development and Refinement

The second phase of research outcomes centered on the project's multi-layered engagement strategy, which included stakeholder workshops, the creation of an online Resource Hub, and case study development. Through these activities, the project team deepened its understanding of community priorities, technical challenges, and the practical realities of implementing equitable gas decommissioning across California.

Stakeholder workshops served as critical forums for surfacing equity and technical priorities. Participants provided direct feedback on the tool's metrics, case study structure, and contextual layers, emphasizing the importance of including socioeconomic vulnerability, climate risk, and community-specific characteristics in the process of screening for decommissioning sites. These workshops also highlighted the need for transparent communication about tool scores and their implications for future decisions, leading to targeted refinements in both the tool's design and its outreach strategy.

The online Resource Hub served as a platform for transparent communication, resource sharing, and accessible education on gas system decommissioning. The Hub was designed to be multilingual and Section 508-compliant, and was set up in order to support stakeholder understanding, built trust, and provided a central feedback mechanism for community review of materials and project updates. Development and use of the platform as part of this research demonstrate how iterative engagement, expert input, and accessible resources can strengthen the technical and equity foundations of statewide energy transition planning.

To build on the equity outcomes described in the previous section, the next part of the report explores in more detail how stakeholder workshops, advisory committee input, and the

development of a public-facing Resource Hub contributed to the project’s research outcomes and strengthened the technical and community foundations of the tool.

Case Studies

The Equity Index was used as a high-level screening tool to identify communities that might illustrate a range of potential impacts and opportunities related to gas decommissioning across the state. This initial screening was then supplemented with additional contextual information about local conditions and considerations in each area. From this combined assessment, the final list of case study locations was shaped by factors such as community interest in participating, available resources, and local capacity for engagement.

The selected sites reflect a broad cross-section of California’s contexts—including urban, rural, suburban, tribal, and regional diversity (Northern, Central, and Southern). Partnering with local organizations willing to engage deeply on highly technical information ensured that community perspectives informed the project’s understanding of local conditions while also supporting knowledge sharing within communities.

This process resulted in five complete case studies—Blue Lake Rancheria, Richmond, Stockton, Central Valley (Visalia and Hanford), and Oxnard—that illustrate a wide range of community experiences and conditions as they related to gas decommissioning. An additional five communities—North Fair Oaks, Sacramento, Wilmington, San Francisco, and the La Jolla Reservation—provided further preliminary insights, offering valuable perspectives despite resource constraints that limited full participation in the case study process. See Figure 12.

Figure 12: Case Study Locations



Communities engaged in the case study process and preliminary outreach. Five communities participated in full case studies, representing a wide spectrum of community experiences and conditions relevant to gas decommissioning. An additional five communities contributed preliminary insights that, despite limited capacity for full participation, offered valuable perspectives to inform tool development and equity-centered planning.

Source: Mindful Gas Decommissioning Research Team

Through this engagement, the research team validated the tool's data, surfaced critical factors, filled data gaps, and incorporated diverse perspectives on costs, risks, benefits, and community impacts. This iterative engagement framework enriched the tool's data-driven analysis by grounding it in lived experience. While census tract-level datasets provide a starting point, they often miss neighborhood-specific realities such as infrastructure conditions, cultural priorities, and emerging land-use patterns. The project team's case study engagement revealed where modeled results aligned with lived experience and where gaps or inaccuracies emerged, ensuring screening outcomes were informed by both technical indicators and community priorities.

Case Studies as a Replicable Framework

Engagement Framework

The engagement process used to develop the case studies followed a structured, iterative framework designed to be replicable across different contexts. It consisted of three rounds of information sharing and listening with each community, each round building on the last. At every stage, the project team synthesized community input, reflected insights back to participants, and validated findings before progressing. This cycle ensured the case studies remained grounded in lived experience rather than assumptions.

Local CBO partners played a central role throughout the engagement. They provided ongoing feedback and formally reviewed each case study, approving the content prior to finalization. This approach established a consistent review and validation process that can be applied in future statewide planning efforts.

The structured sequence—sharing information, gathering input, reflecting findings, and validating results—offers a process that can be consistently applied across diverse communities. By formalizing community review, the approach supports transparency, reinforces data accuracy, and builds trust necessary for long term implementation.

Beyond producing a visualization platform, the tool and its engagement process together form a framework for integrating technical modeling with community-informed insights. This framework is grounded in two core principles:

- **Quantitative–Qualitative Integration:** Technical geospatial and modeling outputs are paired with place-based expertise from local partners. Ground truthing through case studies ensures that modeling aligns with on the ground realities—an essential component of equitable and effective decision making in the energy transition.
- **Iterative Validation:** Each case study demonstrates how statewide indicators can overlook critical local nuance. Through repeated engagement cycles, these gaps are identified and addressed, strengthening both the tool's technical precision and its contextual relevance.

Together, these principles offer an adaptable structure the state can apply as data governance and modeling capabilities evolve. The framework remains transparent and inclusive, ensuring that future decommissioning modeling aligns with the conditions and priorities of affected communities.

Insights From the Case Studies

The case studies contributed insights that extended beyond technical refinements to the tool. They illustrated the varied readiness of communities for gas decommissioning and highlighted the diverse considerations shaping local implementation pathways. Each case surfaced institutional, social, and economic factors—such as limited capacity, cost uncertainty, and questions about community choice—that influence local readiness and are likely to appear across the state.

For example, community partners in Sacramento noted that many rental properties are owned by non-local LLCs, creating challenges for securing owner consent in future decommissioning efforts. Research in Stockton, Visalia, and Hanford showed that in many neighborhoods, housing conditions—combined with moderate financial stability and high reliance on natural gas—point to communities where residents often live in older, lower value homes with aging infrastructure. The prevalence of rental housing and high existing energy burden highlighted the logistical and financial hurdles these households may face in transitioning to electric systems, underscoring the need for tailored, community specific strategies.

In Blue Lake Rancheria, tribal partners emphasized that publicly available data overstated the extent of gas infrastructure in the region, indicating lower levels of pipeline use than state datasets suggested. In places like North Fair Oaks, proximity to wealthier communities such as Menlo Park and Atherton can distort tract level indicators, making localized disparities less visible and potentially lowering tool scores. Similar challenges appeared across rural case study areas, where large census tracts mask neighborhood scale differences: gas service may be concentrated in small pockets, yet aggregated data suggest uniform conditions, and statewide climate datasets often overlook hyperlocal risks—such as flooding, wildfire exposure, or extreme heat—identified by community partners. These cases demonstrate how reliance on tract level data alone can misrepresent vulnerable communities and underscore the importance of pairing the tool with ongoing, place-based engagement to ensure local conditions are accurately reflected. A comprehensive list of case study findings is included in the Community Resources and Equitability Assessment report.

Ultimately, the tool's outputs reveal not only barriers and opportunities but also the complexity behind them, signaling where deeper investigation or engagement may be necessary. When used alongside iterative engagement as illustrated here, the tool becomes part of a comprehensive screening process that supports decision makers in balancing cost, safety, and readiness with equity.

Through this combined approach, the case studies translate the framework into an actionable methodology that can guide future implementation.

Demonstration of a Model Suitable for Statewide Application

The engagement process used in the case studies was essential to validating the tool and demonstrating the value of combining technical analysis with community collaboration. Integrating spatial data with local knowledge bridged the gap between model-driven results and lived experience, enhancing the tool's accuracy and improving understanding of how readiness, risk, and equity intersect at the community level.

Engagement with local partners allowed for metric testing and refinement in real-world contexts, revealing where statewide datasets lacked precision and prompting meaningful adjustments. These exchanges also surfaced local conditions and dynamics—such as resource limitations and differing levels of understanding or comfort with decommissioning—that are critical to implementation planning.

The case study framework offers a model for future efforts by pairing GIS-based analysis with iterative participatory engagement. This approach provides a pathway for the State, utilities, and communities to co-develop equitable, transparent, and locally grounded strategies for priority siting and gas decommissioning.

Ultimately, the case studies show that embedding community insights into technical design strengthens both planning and implementation. This approach provides value in three essential areas:

- **Accuracy:** Community validation helps correct limitations inherent in aggregated datasets.
- **Equity:** Engagement ensures decisions incorporate social and economic considerations, not just technical feasibility.
- **Trust and Transparency:** Collaborative validation fosters confidence among stakeholders and supports durable, community aligned decision-making.

As new data sources and technologies emerge, this engagement framework should be replicated to maintain planning processes that are technically robust, locally relevant, and responsive to community needs. Replication of this model provides a scalable foundation for energy transition planning that aligns state priorities with the diverse conditions of communities across California.

Resource Hub

The online Resource Hub was a platform for transparent communication, resource sharing, and accessible education on gas system decommissioning. The Hub’s multilingual, Section 508-compliant design demonstrated the project’s commitment to equitable information access and became a central feedback mechanism for community review of materials and feedback. This Resource Hub not only improved stakeholder understanding of the tool’s purpose and application but also enhanced trust and legitimacy of the process through transparency and accessibility.

The Resource Hub was designed primarily as a static information and knowledge-sharing platform to support transparency and accessibility of project outputs, rather than as an interactive engagement or outreach tool. As such, the site was not configured with analytics or tracking metrics (for example, visitor counts, unique users, or referral sources) at the time of launch. However, future efforts—especially those engaging emerging regulatory frameworks (for example, SB 1221-related contexts) or broader external audiences—could benefit from incorporating structured “speak-back” mechanisms. These mechanisms could:

- Surface questions or areas of interest from non-core audiences

- Help researchers understand how materials are interpreted or used
- Inform subsequent iterations of research, guidance, or outreach materials

In summary, while the Resource Hub met its intended purpose for this project, future initiatives could reasonably consider implementing interactive features as a way to better understand reach, encourage dialogue where appropriate, and strengthen the overall impact of project communications.

Workshop Two – Importance and Key Results

Workshop 2 served as a major milestone in the Mindful Gas Decommissioning project, providing an opportunity to update community members and stakeholders on project progress and demonstrate how feedback from prior engagement had already been incorporated into the tool. The project team also explained the tool’s architecture, including how data layers are combined and weighted, and how census tract level scores are generated to produce a comprehensive statewide view. A live demonstration illustrated key functionalities such as adjusting indicator weighting, generating custom indices, and exploring specific geographic contexts.

The workshop guided participants through an interactive case study focused on Oxnard to illustrate how quantitative metrics within the Beta tool are “ground-truthed” using local lived experience. Participants examined high equity score census tracts, interpreting how equity, readiness, and asset conditions intersect. A structured Miro board activity introduced reflection questions designed to encourage deeper thought on community specific concerns, without requiring immediate responses due to the complexity of the material.

Using this foundation as a guide, participants were also invited to reflect priorities and concerns related to gas decommissioning efforts in their own communities. Across responses, there was significant emphasis on the importance of involving local communities directly in the process. Participants shared that transparent communication and meaningful engagement were necessary to foster trust and to ensure that impacts—positive or negative—do not fall disproportionately on vulnerable populations. Many participants viewed gas decommissioning as an opportunity to reduce fossil fuel dependence, improve indoor and outdoor air quality, and enhance community safety. However, others expressed concerns about financial burdens, the affordability of transitioning to electric appliances, and the possibility that benefits and burdens may not be shared equitably.

Workshop attendees also provided insight into reasons why residents might be reluctant to no longer use gas in their homes. Community feedback revealed several key factors that shape household and local decision-making around moving away from natural gas use. Participants emphasized that the transition is not viewed solely as a technical or economic issue, but one deeply connected to community identity, trust in government, and perceptions of fairness.

First, concerns emerged around public resistance and local governance, with participants anticipating pushback in city council or community meetings over proposed gas transition efforts. These concerns reflected broader apprehension about perceived government mandates, where some noted that electrification may be seen as a top-down directive rather

than a community driven initiative. Participants emphasized that such perceptions do not arise in a vacuum; rather, they are shaped by long histories of government interventions that have not always aligned with community needs or resulted in positive outcomes. As a result, even well-intentioned policies may be met with caution unless paired with transparent engagement and trust building.

Second, respondents highlighted cultural preferences for gas, particularly for cooking, as an important dimension of household decision-making. This finding underscores that the transition away from gas involves behavioral and cultural adaptation as much as technological change. Finally, participants expressed uncertainty about cost responsibility, identifying a need for clarity on who would bear the financial burden of appliance replacement and home retrofits. This outcome points to the importance of transparent and effective cost-sharing mechanisms and targeted support for low- and moderate-income households to ensure equitable transitions.

Together, these findings suggest that successful gas to electric transitions will rely not only on technical feasibility, but also on honest engagement around uncertainties, including costs, benefits, and potential risks. Communities emphasized that past experiences shape how new initiatives are interpreted, and that transparent communication, shared decision making, and respect for diverse needs and priorities are essential for supporting any transition.

Phase Two Challenges

As the project progressed into Phase Two, the team encountered a range of challenges that shaped both the implementation and refinement of the tool. These obstacles—spanning data limitations, community engagement, infrastructure constraints, and communication barriers—offer valuable lessons for future efforts. The following points summarize key issues that emerged during this phase and highlight considerations for improving equity, effectiveness, and responsiveness in future funding.

In rural areas, large tract sizes can especially dilute the visibility of neighborhood-level disparities. For example, gas service may be concentrated in small pockets, but most tract-level data does not capture sub-tract heterogeneity. Similarly, even within urban areas, many vulnerabilities such as frequent flooding or extreme heat are best understood at the neighborhood or block group level. Feedback from case study partners repeatedly illustrated the importance of consulting with community members to deepen understanding of locally experienced vulnerabilities while grounding data with local expertise.

Navigating data security and consent protocols—especially when engaging tribal communities—required careful planning and sensitivity. These considerations sometimes limited the depth of data collection. Future projects should include clear protocols for data governance, sovereignty, and community-informed consent processes to ensure ethical and respectful engagement.

Compensating and retaining community partners also proved challenging. While the team aimed to establish low-barrier and flexible payment mechanisms, organizational constraints limited the ability to respond effectively to partner needs. In some cases, partners were unable to participate due to a lack of resources. To avoid placing the financial burden on research

teams afterwards and to support sustained engagement, future research solicitations should include larger dedicated, earmarked budgets for community compensation as a part of research grants.

The project encountered unexpected challenges, such as partner withdrawals due to funding cuts and shifting priorities. Building flexibility into project design—through contingency plans and adaptive timelines—can help mitigate risks and maintain momentum when circumstances change.

Conveying the complexity of this project while maintaining clear, non-technical communication with community members presented distinct challenges. For many who were not already engaged in gas decommissioning efforts, the topic was unfamiliar, making it essential to explain both the data and the broader context of gas pipeline decommissioning in accessible terms. To meet this need, the team used an iterative engagement model—through webinars, ongoing outreach, and the online Resource Hub—to ensure transparent communication and integrate local feedback into the tool’s technical design.

Phase Three: Knowledge Transfer

The third phase of the project focused on ensuring that the knowledge, tools, and analytical frameworks developed were effectively transferred to key stakeholders, including state agencies, utilities, community organizations, and researchers. The project’s knowledge transfer efforts resulted in measurable improvements in stakeholder understanding, collaboration, and institutional readiness related to gas system decommissioning in California. Structured engagement with more than 30 CBOs (see APPENDIX D) broadened the project’s equity lens and directly informed case study development, while targeted outreach to IOUs, municipal utilities, and RENs strengthened the tool’s applicability for energy planning and decarbonization efforts across jurisdictions. Public workshops and webinars expanded awareness of gas decommissioning issues among a broad audience, supporting greater transparency and capacity-building for future implementation.

However, the project also identified significant barriers to data longevity that could impact the continued effectiveness of the tool and its equity framework. Since early 2025, federal datasets critical to the Equity Index—such as those from the ACS, DOE LEAD Tool, and FEMA’s Expected Annual Loss dataset—have been subject to systematic purging and less frequent updates. This raises concerns about the future reliability and updateability of the tool’s metrics.

It is important to reiterate that these datasets represent a snapshot in time. The tool was never intended to provide definitive answers on which pipelines to decommission; rather, it serves as a first step for prioritizing targeted analyses and fostering collaborative planning. However, the findings underscore the need for proactive data management and collaboration with external partners to safeguard the integrity and utility of decision-support tools in a rapidly changing data landscape. More detail on this topic is included in Chapter 5, “Conclusion and Recommendations”.

Ultimately, the outcomes of these knowledge transfer activities extend beyond the project’s immediate lifecycle. The engagement process created a broad awareness of the tool’s purpose

and established the conditions for its application by a wider range of stakeholders in the future. Specifically, policymakers and state agencies (for example, CEC, California Air Resources Board, CPUC) may draw on the tool to guide transition planning that considers equity; gas and electric utilities could use it to support system-level decision-making and cost-benefit prioritization; project developers, program designers, and local planners may integrate its outputs into community-scale decarbonization initiatives; researchers can leverage the tool's data framework to advance related analytical methods; and communities and supply chain actors may reference its findings to inform engagement, workforce development, and energy affordability strategies.

Collectively, these outcomes demonstrate the project's value in establishing a shared foundation of knowledge, facilitating ongoing collaboration, and positioning the tool as a credible, flexible resource for California's equitable gas transition. Table 6 summarizes potential future use cases in which the tool could benefit key stakeholders.

Table 6: Study Uses for Key Stakeholders

Study Uses	Stakeholders					
	Policymakers	Gas Utilities	Electric Utilities	Project Developers	Researchers	Communities
Identify more effective policies and programs to overcome barriers, increase benefits, and mitigate impacts.	✓	✓	✓	✓		
Influence policy and program priorities that reflect local social, cultural, workforce, and supply ecosystems.	✓	✓	✓	✓	✓	✓
Demonstrate tools and approaches for selection, review, and prioritization of pilot sites (for example, in compliance with SB 1221).	✓	✓	✓	✓	✓	✓
Demonstrate proven frameworks for reaching and engaging with underserved communities.	✓	✓	✓	✓	✓	✓
Inform integrated energy planning for gas infrastructure investment for an effective and equitable energy system transition, including planning for infrastructure to support load growth from increased energy use and DER proliferation.	✓	✓	✓			

Source: Mindful Gas Decommissioning Research Team

Chapter 4:

Knowledge Transfer

This section documents the completion of the Knowledge Transfer Plan for the tool developed to support strategic and equitable decommissioning of gas infrastructure for the CEC. The objective was to ensure that the scientific and techno-economic analysis and tools developed were effectively transferred and adopted by relevant stakeholders, including state and local agencies, the academic community, and the commercial sector.

The research team was committed to widely sharing the results of the project with stakeholders across California. Throughout the project, the team engaged in extensive outreach, meeting with numerous stakeholder groups and advisory panels to describe the project, share updates, and gather feedback.

Community and Stakeholder Engagement

The research team placed a strong emphasis on community and stakeholder engagement, beginning with the formation of the TAC. The TAC brought together representatives from state agencies, research organizations, utilities, and advocacy groups, and played a pivotal role by providing critical feedback at key stages of the project's development.

Direct engagement extended to more than 30 CBOs from across California, each representing a range of interests including environmental justice, economic development, health, housing, and indigenous issues. The team initiated contact with these organizations via email and followed up with multiple attempts to schedule meetings and briefings. Many of these CBOs responded by participating in the team's public workshops, where they contributed valuable input on both the development of the tool and the design of case studies.

In addition to working with CBOs, the team conducted briefings and informational meetings with IOUs such as PG&E, SoCalGas, and SDG&E, as well as with municipal utilities and community choice aggregators including CleanPowerSF, Peninsula Clean Energy, and Sonoma Clean Power. These interactions help ensure that the tool would be designed to be relevant and useful for utility planning and operations.

RENs, including BayREN, SoCalREN, and 3C-REN, were also briefed on the project. Program managers and administrators from these organizations participated in discussions focused on regional strategies for decarbonization. The team's outreach further included local government representatives, program administrators, and active case study partners, such as CFROG, Renaissance Entrepreneurship Center, Restore the Delta, and Blue Lake Rancheria, all of whom contributed to the project's regional relevance and impact.

Public Outreach

The research team actively promoted public outreach and knowledge sharing throughout the course of the tool's development. DNV organized multiple public workshops and webinars, drawing a broad audience that included community representatives, policymakers, and technical experts. Materials and recordings from these workshops were made available

through the Resources Hub website. These events served as platforms to raise awareness about gas decommissioning, present key project findings, and invite feedback on both the usability of the tool and its policy implications.

For example, the public webinar to showcase the tool held on October 8, 2025, was actively marketed to a distribution list of 200+ people, promoted on LinkedIn, and promoted in the CEC's DACAG (Disadvantaged Communities Advisory Group) Newsletter.

Additionally, the tool has also been highlighted at a California Efficiency + Demand Management Council industry training course, *Energy Efficiency & Demand Management Policy & Practice in California*, provided on September 16, 2025 (California Energy and Demand Management Council n.d.). The tool was mentioned during a training session titled *Equity, Environmental & Social Justice Initiatives at CA Energy Agencies*.

Tool Transfer Meeting

On October 28, 2025, the project team held a Tool Transfer meeting with staff from the CEC and CPUC. The purpose of the meeting was to provide a comprehensive overview of the tool with a particular focus on its features, applications, and procedures for updating and extracting data.

The meeting's primary objectives were to showcase the tool's key features through a live demonstration, review the accompanying user manual and technical documentation, and illustrate how the tool can be leveraged to address critical research questions related to gas asset management and equity. The demonstration highlighted the tool's interactive mapping capabilities, its integration with ArcGIS for spatial analysis, and its support for community case studies and equity indices. Participants were shown how to navigate the interface, utilize search and bookmarking functions, add new data, and generate analytical charts.

A significant portion of the meeting was dedicated to discussing the processes for updating and extracting data within the tool. The project team provided step-by-step guidance on how users can maintain and expand the tool's datasets, helping ensure data integrity and confidentiality. The user manual and technical documentation were reviewed to support future users in these tasks.

Chapter 5:

Conclusion and Recommendations

Conclusions

This report concludes that the tool provides a robust framework for identifying and prioritizing potential gas decommissioning zones across California. It supports both statewide and local planning efforts, offering actionable insights for decision-makers. This perspective allows state decision-makers and energy system planners to quickly identify areas with the highest overall readiness scores between different utility service territories, highlighting locations where decommissioning is likely to be most feasible and beneficial.

Alternatively, “bottom-up” evaluations start with specific infrastructure assets and expand outward to assess the likely community-scale benefits and impacts associated with their decommissioning. A bottom-up use of the tool begins with examining specific local areas to understand how different factors interact to shape the implications of a gas to electric transition for the people who live there. This approach allows users to start at the local level and use the tool to uncover the unique conditions, vulnerabilities, and opportunities present in each area. One of the tool’s key strengths is that variation in scores—whether high or low—does more than reveal barriers or advantages. These patterns expose underlying complexities that may not surface through a top-down analysis alone, signaling where further engagement, localized discussion, or deeper investigation is needed. When used this way, the tool helps illuminate tensions between different considerations, such as the interplay between factors such as safety, building readiness, environmental burden, and socioeconomic vulnerability, prompting a more balanced and context sensitive understanding of what a transition might mean on the ground.

Beyond this, the tool has been deliberately designed and architected to be interoperable with other data resources and tools. This means that it can readily import data from external sources, both public and private, to be used as additional context for the interpretation of the indices developed as a product of this research project. It also means that this project’s research data products can be exported for use in other external tools or platforms. The research team expects that this interoperability will be hugely important in bridging the gap between the need for private tools, to perform detailed analysis using confidential gas customer and asset information, and the need for public tools, to facilitate discussions with community members and organizations about decommissioning site selection priorities and opportunities. This interoperability is a key conclusion of the report, as it enables integration across planning tools and supports both confidential analysis and public engagement.

Relative to both potential use cases (public versus private), the geospatial representation of each index—Equity, Residential and Non-Residential Readiness, and Gas Assets—can be viewed independently or overlaid, depending on the user’s objectives. The ability to combine equity, readiness, and asset indicators is a central finding, as it allows for strategic prioritization across multiple scales.

Significantly, in each case study conducted in this project, the research team collaborated with community partners to conduct an initial screening for potential high-priority areas, based on the tool's scores and community knowledge of local neighborhood and infrastructure characteristics. This allowed the team to develop a nuanced understanding of how gas asset conditions, decommissioning readiness, and equity factors intersect at the local level. This form of iterative collaboration and consultation with community members is a critical component of equitably decommissioning pipelines throughout the State and should remain a key priority as the CEC moves forward with long-term gas planning and decision-making, including implementation of decommissioning pilots under SB 1221. This collaborative approach is a critical conclusion, demonstrating the importance of community engagement in equitable decommissioning efforts.

In summary, the tool offers a scalable, flexible, and equity-informed approach to gas decommissioning planning. It provides clear pathways for both immediate and long-term decision-making, and its use can inform broader statewide strategies.

Benefits and Importance of the Project Outcomes to California's Clean Energy and Climate Goals

This project was designed as a research project to examine data and factors relevant to screening for potential sites for decommissioning gas assets. It was already in progress when SB 1221 was signed into law by Governor Newsom in 2024. Passage of SB 1221 underscored the need for a tool or tools that could help identify priority sites, to provide interoperability between IOU maps and other data sets, and/or to support bottom-up outreach and engagement as discussed in the prior section. Such functionality offers valuable insights into how specific local factors affect a region's overall preparedness for decommissioning.

The research team worked closely with the CEC and CPUC staff to stay abreast of changing gas planning and transition policy to ensure that the tool was responsive. For example, SB 1221 establishes provisions for prioritizing disadvantaged communities and tribal areas within the 30 pilot projects gas utilities must implement. It also requires consideration of environmental justice, energy burden, and community readiness factors. Among other uses, the tool has great value in its ability to make these criteria visible and actionable, translating statutory requirements into a clear, data-driven framework for comparison across communities. Supported by the research's case study analysis framework, the tool is well-suited to guide the screening and selection of pilot sites, ensuring alignment with state policy priorities of prioritizing disadvantaged, underserved, at-risk, and vulnerable communities and ensuring equitable implementation statewide.

Considerations Regarding Future Applications of the Tool

Future Uses

As designed, the tool is an interactive website with a "map-first" interface that illustrates how multiple spatial decision criteria interact to produce different screening outcomes. Its future value lies in providing a statewide view of areas where gas decommissioning appears most promising under the specific combination and weighting of criteria applied within the tool—

including safety, equity, readiness, and cost-related indicators such as district average cost per mile to replace pipeline.

Under current practice, utilities prioritize pipeline replacement based on risk assessments conducted through their Distribution Integrity Management Programs⁷, which emphasize safety-related factors such as leak risk, pipe material, and pipeline age. These high-risk segments may also represent locations where decommissioning could be considered as an alternative to replacement, potentially redirecting planned replacement expenditures toward permanent system reductions. The tool enhances this approach by allowing users to move beyond safety and risk mitigation. The tool highlights where interventions can simultaneously reduce risks to the system and to vulnerable households, as well as improve public health outcomes—benefits that might otherwise be overlooked. Integrated into a screening process, the tool could support decision-makers with the additional information needed to balance more traditional cost and safety-oriented perspectives with customer readiness and equity considerations.

Additionally, the research team envisions that the tool can be used to identify locations for future or “next tier” site identification. For instance, the tool can be used to highlight areas with elevated safety risks, but without active replacement or repair projects. In these situations—such as multiple areas showing similar safety profiles or equivalent levels of technical readiness—the tool’s Equity Index can help guide prioritization by distinguishing where certain communities may merit earlier or more careful attention.

Importantly, using the Equity Index in this way does not assume that communities with higher burdens will automatically benefit from decommissioning, nor that the transition will be risk free. Rather, it helps identify where additional engagement, context specific analysis, and careful assessment of potential risks—such as energy affordability, resilience, or transition related burdens—may be especially important before any decisions are made. High Equity scores can signal where the stakes for communities may be higher, not where outcomes are predetermined. This allows decision makers to compare otherwise similar locations and determine where deeper inquiry, protective measures, or early planning efforts might be warranted to ensure that any future transition is both responsible and responsive to community conditions.

To date, much of the deliberations around gas decommissioning project site selection has occurred either behind closed doors, amongst IOU engineers, or among an esoteric community of academic researchers and energy system planners. With the passage of SB 1221, however, which authorizes the development of real-world decommissioning pilot projects throughout the state’s IOU territories, there is a new sense of urgency around the need for decision support

⁷ Distribution Integrity Management Programs are required under federal pipeline safety regulations—specifically [49 CFR Part 192, Subpart P](https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-D/part-192/subpart-P) (<https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-D/part-192/subpart-P>)—and are enforced in California through the CPUC’s adoption of [federal standards and General Order 112-F](https://www.cpuc.ca.gov/regulatory-services/safety/gas-safety-and-reliability-branch/pipeline-rules-and-regulations), documented at: <https://www.cpuc.ca.gov/regulatory-services/safety/gas-safety-and-reliability-branch/pipeline-rules-and-regulations>. For example, SoCalGas notes that its [SB 1221 pipeline mapping](https://www.socalgas.com/regulatory/SB1221Map) incorporates segments identified using preliminary DIMP risk analyses: <https://www.socalgas.com/regulatory/SB1221Map>.

tools to help guide this transition in transparent ways that can foster public support and engagement.

It is highly unlikely that viable sites for gas decommissioning projects will be able to be identified by utilities and energy system planners alone, without extensive community engagement. More probably, viable candidate sites will be able to be identified through an iterative process involving multiple rounds of community and stakeholder engagement paired with supporting technical analysis.

As the project team's work in developing the tool has demonstrated, this iterative process could potentially be initiated at different levels of geographic detail. For instance, an initial high-level "top-down" statewide perspective provides a map of composite index scores, representing the combined contributions of the four key indices. Low and high scoring census tracts are made clearly visible, and the tool can be used to further filter the data and identify hotspots across the State—areas with high concentrations of census tracts that should be considered promising for gas decommissioning based upon their respective scores.

Once this initial group of hotspots has been located, the tool can then be used from a "bottom-up" view, to identify specific promising census tracts. This process involves a detailed inspection of individual tracts' component sub-index scores, or even raw variable scores to better understand their respective contributions to each overall composite score.

Specifically, the tool provides a set of added values that are complementary to other utility-specific tools currently available and in use. Critically, the tool provides a broader geographic scope and lacks significant privacy concerns. Unlike existing models, the tool also emphasizes breaking down siloes to bridge the human and technical dimensions of gas transition policies.

As the state moves forward with site selection activities under gas transition policies, the tool provides several key differentiators over current models, tools, and studies. This includes its ability to overcome energy system fragmentation by integrating data from multiple domains: gas infrastructure, equity, and existing building energy use characteristics (within the decommissioning readiness indices). The data integration framework formed the foundation for this project's co-creation of site-specific case studies across the State and offers an adaptive roadmap for effective project implementation that emphasizes flexibility and responsiveness when engaging with communities on complex issues.

Considerations with Respect to State Policy

Building on the findings and insights developed through this research, the following considerations are intended to facilitate leveraging the tool to support equitable and effective implementation of gas system decommissioning policy. These considerations focus on how the research teams envision that the tool could be used to inform site identification, selection, funding decisions, and community and stakeholder engagement, ensuring that

decommissioning efforts are data-driven, community-informed, and aligned with statewide policy goals. Specifically, the tool could be used to:

- Contextualize utility-defined gas asset decommissioning priorities to identify and compare potential candidate sites based on safety, equity, readiness, and cost-effectiveness.
- Direct funding efficiently, by aligning decommissioning with areas of highest safety risk and leveraging the Equity Index to ensure equity considerations guide both current and future project selection.
- Help ensure that state policy objectives, such as those associated with SB1221, are met by prioritizing disadvantaged, underserved, at-risk, and vulnerable communities that face the greatest energy and health burdens.
- Balance diverse stakeholder concerns—including those of IOUs, municipalities, community groups, developers, technology vendors, and regulators—by providing a transparent, data-driven foundation to inform site selection.

Using the tool in these ways can support pilot decommissioning projects that are not only technically sound; but also equitable, transparent, and responsive to community needs.

Lessons Learned with Respect to Community Engagement

The project's engagement experience across diverse regions and community partners offers several important lessons for how the State can strengthen future community informed energy transition efforts. First, the project team's work underscores that communities are fully capable of engaging with complex, technical information when provided the opportunity and appropriate context. Across all case study locations—rural, urban, and tribal—local partners demonstrated deep subject matter knowledge, sophisticated understanding of energy and environmental issues, and ongoing involvement in related advocacy or planning work. The challenge, therefore, is not a lack of community capacity. Instead, it lies in designing engagement processes that recognize, respect, and leverage the expertise already present in communities, rather than assuming a need to “simplify” or limit discussions. A more effective state approach begins with acknowledging community partners as technical contributors, not passive stakeholders.

A second lesson concerns the type of expertise needed to facilitate meaningful engagement on a topic as complex as gas system decommissioning. The project team experimented with dividing facilitation roles between technical experts and engagement specialists, but this structure often created communication gaps, fragmented discussions, or slowed the exchange of information. Efforts of this nature require facilitators who can bridge both domains—individuals who can understand technical content deeply while also communicating it clearly, building trust, and guiding collaborative dialogue. This hybrid “technical plus engagement” expertise is relatively rare, but essential for coherent, productive discussions. Without it, even well designed engagement strategies risk miscommunication or missed opportunities to clarify key issues.

Third, effective stakeholder engagement requires adequate funding and dedicated resources. Throughout the project, engagement budget limitations shaped the level of participation the team could secure from subcontractors and community partners. In one case, a potential partner indicated they could support only local—not statewide—engagement efforts within the available community engagement budget for this effort. This experience highlighted a broader structural issue: while iterative and meaningful engagement requires more upfront investment, it consistently produces stronger project outcomes, higher community buy in, and more actionable insights into real world conditions. Under resourcing these efforts can constrain who participates, limit geographic reach, and reduce the quality of insights that ultimately inform state decision making. Future statewide transition efforts should plan deliberately for the true cost of engagement and ensure partners are adequately compensated for their time and expertise.

Finally, the project revealed structural barriers that commonly hinder state community dialogue. State agencies often operate within regulatory and policy constraints that limit what they can commit to or promise to communities. At the same time, community organizations—especially those representing historically burdened populations—may understandably ask for more than the state can provide, based on long histories of unmet commitments or harmful interventions. These tensions often result in the state defaulting to “inform only” models of engagement, where communities are briefed but not meaningfully involved in shaping decisions. This is a missed opportunity. Even when agencies cannot meet all community requests, creating space for honest, transparent, two-way dialogue builds trust, improves policy design, and helps communities understand constraints and timelines. Maintaining open communication—rather than retreating to one way information sharing—should be a core principle of future state led engagement.

Taken together, these lessons point to a set of clear recommendations: recognize and elevate community expertise; invest in facilitators who can bridge technical and relational domains; resource engagement adequately; and commit to dialogue even within policy and regulatory limits. Embracing these practices will help ensure that gas transition planning is not only technically sound, but also grounded in the lived experiences, priorities, and insights of the communities most affected by the energy transition.

Why the Data Sources Represent a Snapshot in Time and Require Ongoing Maintenance

The tool draws from over a dozen trusted datasets—including IOU customer metered energy usage data, CPUC rulings, CalEnviroScreen, FEMA, ACS, and DOE LEAD tools—to reflect customer characteristics, infrastructure realities and community vulnerabilities. While this diversity strengthens the tool’s analytic framework, these datasets represent a snapshot in time, primarily from the early 2020s, because the research began in 2022 and relied on the best available data at that point. The tool was never intended to provide definitive answers on which gas pipelines or assets to decommission; rather, it serves as a first step at developing a robust quantitative framework for weighing competing site selection criteria and fostering collaborative planning.

However, the project team identified significant barriers to data longevity. The tool's Equity Index relies on at least 30 primary metrics or variables directly from federal data sources that have been impacted by recent data purges. Since early 2025, the current administration has carried out widespread removals and alterations of federal datasets across demographic, environmental, climate, health, and diversity equity and inclusion-related topics. By mid-2025, government agencies had taken down or modified approximately 3,000 datasets, with estimates indicating that more than 8,000 federal web pages were also removed or altered during this period (Palmer 2025). This raises questions about the efficacy of the Equity Index in the future if updated sources of data are unavailable. Among others, this includes multiple variables related to socioeconomic vulnerability and environmental risk from the American Community Survey, energy burden data from the DOE LEAD Tool, and climate risk data from FEMA's Expected Annual Loss dataset.

Multiple groups have been working to download and provide continued, though unofficial, access to these data sets. Among others, these groups include organizations such as the Open Environmental Data Project, Data Rescue Project, Safeguarding Research and Culture, the Internet Archive, the End of Term Archive, and the Data.gov Archive, run by the Harvard Law School Library (Palmer 2025). Future versions of the tool could seek out and access such data, though uncertainty remains about how many of these databases will be updated in future years.

To safeguard its utility, ongoing investment is needed to:

- Maintain and update core datasets
- Collaborate with data preservation organizations
- Secure access to backed up or alternative sources

These actions are essential to ensure that decision-support tools remain robust, transparent, and effective in guiding California's just energy transition.

Implications of Project Outcomes

The outcomes of this research indicate how a data-driven approach could help translate state decarbonization policies into actionable, community-informed planning. While the tool has not yet been applied in implementation, it provides a screening framework aligned with California's climate and energy transition policies (for example, SB 1221 and the CPUC's Gas Distribution Infrastructure Decommissioning Framework [CPUC 2022c]), supporting exploration of transparent, equitable, and cost-aware pathways to gas asset decommissioning.

Through extensive stakeholder and community engagement—including three statewide webinars and direct outreach to 38 community based and regional organizations—the project has not only advanced technical understanding of gas decommissioning readiness but also helped build awareness of emerging transition policies among communities, local leaders, and utilities across California.

This iterative process surfaced key social and institutional barriers—including limited capacity, uncertainty about costs, and perceived loss of choice—that can shape community positions

toward decommissioning. Understanding these factors is essential for designing equitable transition pathways and ensuring that technical feasibility aligns with local readiness and values.

The tool and its supporting analyses help policy implementers—including utilities, regulators, and community partners—identify candidate pilot sites that are both technically viable and socially and environmentally impactful in terms of expected benefits. By integrating metrics on gas asset condition, equity, and readiness, the tool supports evidence-based prioritization of decommissioning opportunities. For example, areas with both high safety risk and high equity scores may represent strong candidates for early action, while locations facing high stranded asset risks—such as communities surrounded by early adopters of electric energy systems—can be identified for proactive intervention to prevent cost-shifting onto vulnerable ratepayers.

Taken together, these outcomes position the tool as a bridge between high-level policy intent and on-the-ground implementation. By layering technical, social, and equity data, it enables California to balance broad-scale cost efficiency with strategic, place-based decision-making. Because the tool's design and data have been informed through community validation, it also contributes to the trust and accountability needed for durable policy rollout. In this way, the project lays critical groundwork for an informed, inclusive, and equitable transition away from natural gas infrastructure.

Benefits of Lessons Learned and Future Development Opportunities

This research project has developed the start of a strong foundation: a snapshot of high-quality data that underwent rigorous community validation as the project progressed. Looking ahead, the next step is to ensure the strategic and ongoing development and application of the tool—not just to identify potential pilot projects for gas asset decommissioning, but as a long-term resource for gas system planning and investment decisions. Moving forward, there are opportunities to improve and update that data over time, leveraging community insights and the feedback gathered throughout this research so that community voices remain central to shaping both the technical and policy dimensions of this work.

A second opportunity lies in encouraging broader implementer use. Utilities, state agencies, and local governments could apply the tool to screen for promising candidate sites and integrate their own datasets to refine feasibility assessments and inform next-stage planning.

Finally, the team considers that there is value in refining the tool for broader access and transparency. During case study engagement, multiple community-based organizations expressed clear interest in gaining access to the tool as they actively pursue decommissioning projects at the local level. Because it was built on public data and data aggregated to eliminate privacy concerns, making the tool available to communities, researchers, and advocates will expand its impact and support more inclusive participation in California's energy transition.

Ultimately, this tool is not just a technical resource—it could serve as a platform for collaboration, accountability, and equity. There is a strategic opportunity to use it to guide California's gas transition in a way that is informed, inclusive, and just.

Glossary and List of Acronyms

Acronym	Term	Definition
ACS	American Community Survey	Census Bureau survey providing demographic and housing data.
AGOL	ArcGIS Online	Cloud-based GIS platform hosting the developed tool and accompanying datasets.
CARB	California Air Resources Board	State agency for air quality and climate policy.
CBO	Community-Based Organization	Nonprofits representing local interests such as environmental justice and housing.
CCA	Community Choice Aggregator	Local agencies procuring electricity with a focus on renewables.
CCSC	California Center for Sustainable Communities	The University of California at Los Angeles' Research Center focused on sustainable urban systems and energy equity.
CEC	California Energy Commission	The state agency responsible for energy policy, planning, research, and development in California. The CEC funds and oversees projects related to energy efficiency, renewable energy, and infrastructure transition, including the mindful gas decommissioning project.
CEDMC	California Efficiency + Demand Management Council	Industry association for energy efficiency and demand management.
CEUS	Commercial End-Use Survey	Survey of commercial energy consumption patterns.
CPUC	California Public Utilities Commission	The regulatory authority for privately owned utilities in California, including electricity, natural gas, telecommunications, water, and transportation. CPUC sets policy, oversees compliance, and manages rulemakings such as the long-term gas planning proceeding.

Acronym	Term	Definition
DAC	Disadvantaged Community	Areas throughout California that most suffer from a combination of economic, health, and environmental burdens. These burdens include poverty, high unemployment, air and water pollution, presence of hazardous wastes as well as high incidence of asthma and heart disease. One way that the state identifies these areas is by collecting and analyzing information from communities all over the state. CalEnviroScreen, an analytical tool created by the California Environmental Protection Agency (CalEPA), combines different types of census tract-specific information into a score to determine which communities are the most burdened or “disadvantaged”.
DER	Distributed Energy Resource	Local energy resources like solar panels and batteries.
DIMP	Distribution Integrity Management Program	Federally required, risk-based safety program that natural gas distribution operators must develop and implement under 49 CFR Part 192, Subpart P to ensure the safe operation of their distribution pipeline systems. It requires operators to understand their systems, identify and rank threats, address risks, and continuously monitor and improve system integrity.
DNV	DNV Energy Insights, Inc.	International energy consultancy leading technical design and stakeholder engagement, that led this research.
DOE	U.S. Department of Energy	Federal agency overseeing energy policy and research.
E3	Energy + Environmental Economics	Consulting firm specializing in energy modeling and policy.
EAL	Expected Annual Loss	FEMA metric estimating annual losses due to climate impacts.
EIA	U.S. Energy Information Administration	Federal agency providing energy statistics.
EPA	U.S. Environmental Protection Agency	Federal agency for environmental protection.

Acronym	Term	Definition
FEMA	Federal Emergency Management Agency	Federal agency for disaster response and risk assessment.
GIS	Geographic Information System	Technology for mapping and analyzing spatial data.
HCA	High Consequence Area	Areas near pipelines with higher human consequences in accidents.
IOU	Investor-Owned Utility	Privately owned energy utilities regulated by the CPUC.
kWh	Kilowatt-hours	Unit of energy that represents the amount of electricity consumed when a device with a power rating of one kilowatt (1,000 watts) operates for one hour.
MCA	Moderate Consequence Area	Moderately populated areas or major roads near pipelines.
MCDA	Multi-Criteria Decision Analysis	Framework for evaluating decisions with multiple criteria.
MECS	Manufacturing Energy Consumption Survey	National survey of manufacturing energy use.
MF	Multi-Family (housing)	Residential buildings for multiple families.
NAICS	North American Industrial Classification System	Classification scheme providing detailed information about the nature of business or production activities at a customer premise.
NDA	Non-Disclosure Agreement	Legal agreement protecting confidential data.
NREL	National Renewable Energy Laboratory	Federal lab specializing in renewable energy research.
OLS	Ordinary Least Squares	Statistical method used in regression analysis to estimate the relationship between one or more independent variables and a dependent variable.
PAC	Policy Advisory Committee	Advisory group intended to provide policy guidance and feedback.
REN	Regional Energy Network	Local government collaborations delivering energy efficiency programs.

Acronym	Term	Definition
RMP	Risk Management Program	Federal program regulating hazardous chemical facilities.
SB 1221	California Senate Bill 1221	Legislation requiring prioritization of disadvantaged communities in gas decommissioning.
SF	Single-Family (housing)	Residential buildings for single families.
SHE	Self-Help Enterprises	Californian community-based organization contributing local knowledge and equity-focused insights.
TAC	Technical Advisory Committee	Expert panel advising on data, methodology, and tool development.
UCLA	University of California, Los Angeles	Public university in Los Angeles, California. In this report specific reference is made to California Center for Sustainable Communities (CCSC) within UCLA's Institute for the Environment and Sustainability, which was instrumental in development of the tool.
USDA	U.S. Department of Agriculture	Federal agency for agriculture and rural development.

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Project Deliverables

Below is a list of project deliverables by task as outlined in the Scope of Work. Project deliverables, including interim project reports, are available upon request by submitting an email to pubs@energy.ca.gov.

- Gas Assets Assessment Data Collection and Analysis Plan and Report*
- Decommissioning Readiness Assessment Plan and Report*
- Case Study Engagement Plan and Report*
- Secondary and Tertiary Metrics Report (*public version titled: Indices and Sub-indices Design and Development Memorandum)
- Information Security Program Plan
- Review of Existing Relevant Tools Memorandum
- Data-Driven Tool Technical Requirements Memorandum
- User Manual for the Data-Driven Tool (included within the Tool)
- Data-Driven Tool Report*
- Data Product Management Plan
- Knowledge Transfer Plan
- Technology Transfer Report

Deliverables marked with an asterisk (*) have been made available via the California Energy Commission's Healthy, [Equitable Energy Transition \(HEET\) Working Group website](https://www.energy.ca.gov/programs-and-topics/topics/research-and-development/healthy-equitable-energy-transition-heet), under the *Past CEC-funded Research* pull-down: <https://www.energy.ca.gov/programs-and-topics/topics/research-and-development/healthy-equitable-energy-transition-heet>

The project researchers also documented a number of the project findings in a peer-reviewed publication:

E.D. Fournier, J. Moul, M. Ofek, J. Skrovan, S. Mathews, R. Cudd, S. Pincetl. 2026. [Prioritizing sites for gas distribution system decommissioning projects using geospatial data and decision support tools](https://doi.org/10.1016/j.jup.2026.102322). Utilities Policy. Volume 103, 102322. ISSN 0957-1787. <https://doi.org/10.1016/j.jup.2026.102322>.



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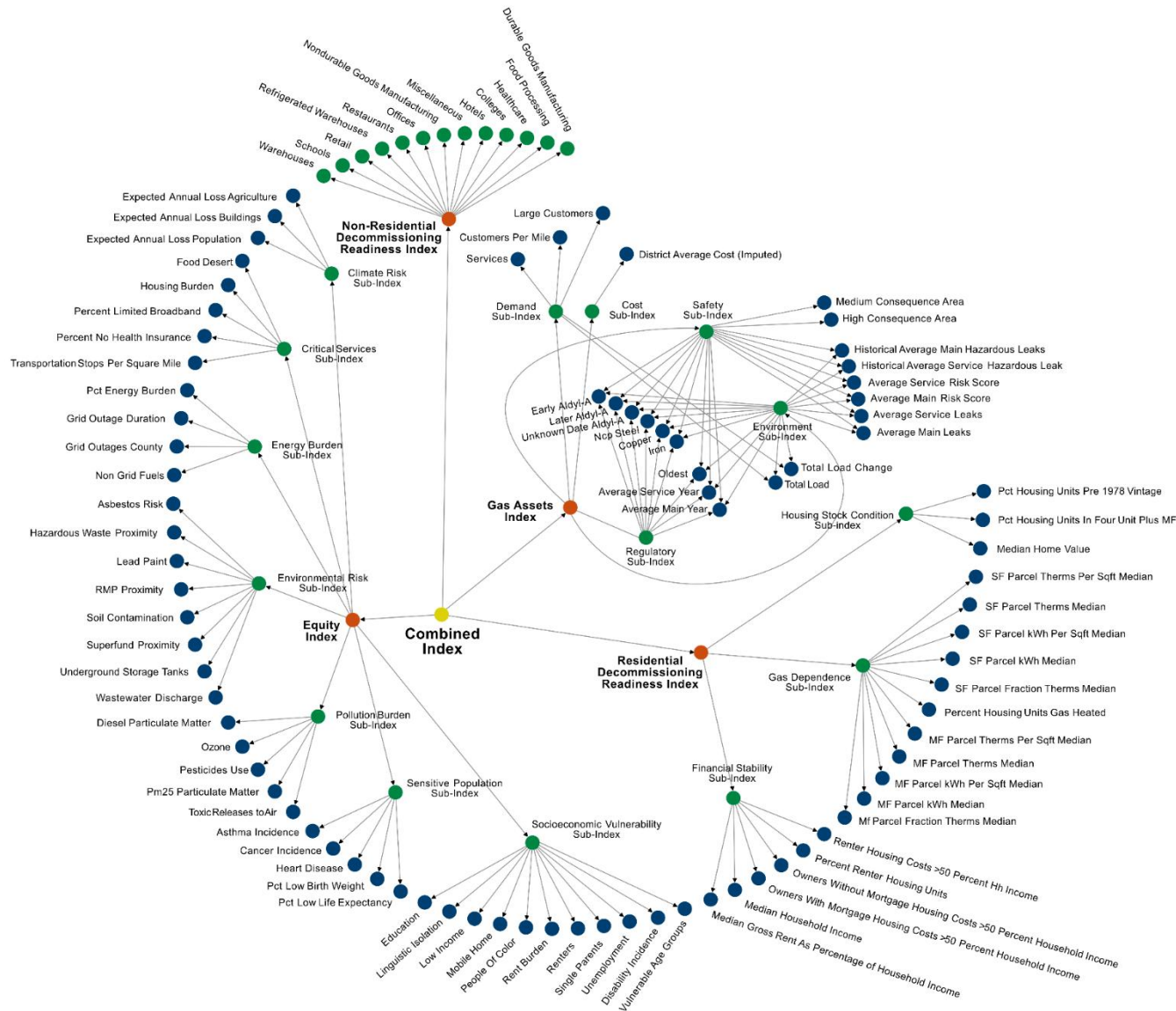


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APPENDIX A: Network Diagram Depicting the Mapping of Indices, Subindices, and Variables

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APPENDIX A: Network Diagram Depicting the Mapping of Indices, Subindices, and Variables





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APPENDIX B: Variable Descriptions

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APPENDIX B:

Variable Descriptions

Variable descriptions for the Equity Index include:

- **Education:** Percentage of households who are 25 years old or with less than a high school education
- **Linguistic isolation:** Percent of households that speak English less than "very well"
- **Low income:** Percent of families below the poverty level
- **Mobile homes:** Percent of households that live in mobile homes
- **People of color:** Percent of population that is non-white
- **Rent burden:** Percent of households paying more than 35% of gross income on rent
- **Renters:** Percent of households occupied by renters
- **Single parent:** Percent of households with a single parent
- **Unemployment rate:** Annual unemployment rate by county
- **Energy burden ratio:** Household ratio of energy expenditures to gross income by census tract
- **Grid outage duration:** Average duration of grid outages in this county
- **Grid outages county:** Number of grid outages in this county
- **Non-grid fuels:** Percentage of households that use non-grid fuels to heat their home, which include natural gas, propane, liquid gas, wood
- **Diesel particulate matter:** Percentile of households exposed to diesel particulate matter
- **Ozone:** Concentration of ozone by census tract
- **Pesticides use:** Percentile of census tracts affected by pesticide exposure
- **PM2.5 particulate matter:** Percentile of census tracts affected by PM 2.5 concentration
- **Toxic releases to air:** Toxic release to air by census tract
- **Asbestos risk:** Percentage of households in residential buildings older than 1978 who have a higher likelihood of asbestos exposure
- **Hazardous waste proximity:** Proximity to hazardous waste disposal sites
- **Lead paint:** Percentage of homes at risk of lead paint exposure using the proxy of 1950s building vintages
- **RMP proximity:** Proximity to Risk Management Program (RMP) facility

- **Soil contamination:** Soil contamination from groundwater threats
- **Superfund proximity:** Proximity to a U.S. EPA Superfund site
- **Storage tanks:** Proximity of households to underground storage tanks
- **Wastewater discharge:** Toxicity weighted concentration of wastewater discharge in nearby waterways
- **Asthma incidence:** Percentile of households affected by asthma by census tract
- **Cancer incidence:** Percentile of households affected by cancer by census tract
- **Heart disease incidence:** Percentile of households with heart disease incidence by census tracts
- **Low birth weight:** Percentage of babies born with low birth weight
- **Low life expectancy:** Percentile of households with low life expectancy by census tract
- **Food deserts:** Limited access to supermarkets, supercenters, grocery stores, or other sources of healthy and affordable food that may make it harder for some people to eat a healthy diet
- **Housing burden:** Households who are low income and burdened by housing cost.
- **Limited broadband:** Percentage of homes with limited broadband access
- **Health insurance:** Percentage of homes without health insurance
- **Transportation stops:** Transportation stops per square mile by census tract
- **Expected annual loss – agriculture:** Expected dollar value annual loss of agriculture due to climate impacts by census tract
- **Expected annual loss – buildings:** Expected dollar value annual loss of buildings due to climate impacts by census tract
- **Expected annual loss – population:** Expected dollar value annual loss of populations due to climate impacts by census tract

Variable descriptions for the Gas Assets Index include:

- **EarlyAldylA:** Miles of distribution main and service pipeline made of Aldyl-A plastic installed in 1965-1972
- **LaterAldylA:** Miles of distribution main and service pipeline made of Aldyl-A plastic installed in 1973-1985
- **UnkDateAldylA:** Miles of distribution main and service pipeline made of Aldyl-A plastic with unknown manufacturer or installation year
- **NCPSteel:** Miles of distribution main and service pipeline made of steel without cathodic protection

- **Copper:** Miles of distribution service pipeline made of copper
- **Iron:** Miles of distribution main and service pipeline made of wrought iron
- **AvServiceRiskScore:** Risk score averaged across distribution service pipeline miles
- **High consequence area (HCA):** Overlaps an HCA, which is a populated area near transmission pipelines, where accidents would have higher human consequences
- **Moderate consequence area (MCA):** Overlaps an MCA, which is moderately populated areas or four-lane road near transmission pipelines
- **DistAvCost:** Average cost per mile to replace distribution pipeline in the Division (PG&E), Operating District (SoCalGas), Construction and Operations Center serving the census tract (SDG&E), or Jurisdiction (SW Gas).
- **AvMainLeaks:** Main leaks identified in leak surveys, excluding repaired or removed leaks, averaged across distribution main pipeline miles
- **AvServiceLeaks:** Service leaks identified in leak surveys, excluding repaired or removed leaks, averaged across distribution service pipeline miles
- **HistAvMainHazLeaks:** Main hazardous leaks (grade 1) repaired in 2015-2020, averaged across distribution main pipeline miles
- **HistAvServiceHazLeaks:** Service hazardous leaks (grade 1) repaired in 2015-2020, averaged across distribution service pipeline miles
- **AvMainYear:** Year pipeline was installed, averaged across distribution main pipeline miles
- **AvServiceYear:** Year pipeline was installed, averaged across distribution service pipeline miles
- **Oldest:** Miles of distribution main and service pipeline older than 1941 or with unknown installation date
- **TotalLoad:** Average annual daily gas consumption in 2021
- **LoadChange:** Annual gas demand change from 2015 to 2020
- **Number of customers:** Proxied by "Services" field, which is described as "Number of services (count)—Services typically serve one customer each"
- **Customers per mile:** Field calculated by dividing Services by the sum of MedPressMains and MedPressServices. MedPressMains is defined as "Miles of medium pressure (60 psi or below) distribution main pipeline" and MedPressServices is defined as "Miles of medium pressure (60 psi or below) distribution service pipeline".

Variable descriptions for the Residential Readiness Decommissioning Index include:

- **Percentage of total housing units that are in 4+ unit multi-family buildings:** The assumption relative to this variable is that census tracts with a larger proportion of inhabitants living within larger multi-family buildings should be considered less ready for

gas decommissioning as these types of properties are structurally more difficult to electrify and must content with split incentives (between owners and occupants) in terms of the costs and benefits from doing so.

- **Percentage of total housing units that were built prior to 1978:** The assumption relative to this variable is that census tracts with a higher proportion of total housing units built before to 1978 (prior to the introduction of California's statewide Title-24 building energy codes) are likely to have been constructed with smaller capacity electrical service panels that are less ready to integrate new electrical appliance loads without the need for costly capacity upgrades or other panel size optimization strategies.
- **Median home value:** The assumption relative to this variable is that census tracts with higher median home values are likely to have received more extensive and more recent building retrofit measures resulting in the improved thermal shell efficiency, end-use energy appliance efficiency, as well as higher-capacity building electrical system components (service panels, wiring, outlet receptacles, etc.) reducing the effective barriers to gas-substitute end-use electrical appliance integration.
- **Median household income:** The assumption relative to this variable is that census tracts with higher median household incomes will have greater access to financial resources necessary to facilitate the up-front purchase of gas substitute equipment, as well as to make any necessary property renovations/retrofits necessary to accommodate their installation.
- **Percentage renter housing units:** The assumption relative to this variable is that census tracts with a higher percentage of renter housing units will have greater challenges in terms of initiating and completing gas-appliance substitution projects, due to the split-incentives between property owners and renters in terms of these types of building energy system alteration projects.
- **Median gross rent as a percentage of household income:** The assumption relative to this variable is that census tracts with higher median gross rents as a percentage of household income will have a larger population facing financial constraints in terms of the cost of implementing the types of fuel-substitution measures that would likely be required to participate in a decommissioning project.
- **Homeowners with mortgage housing costs that are greater than 50% of their household income:** The assumption relative to this variable is that census tracts with a larger number of homeowners whose housing costs are greater than 50% of their household income will be more financially constrained in terms of initiating the types of fuel-substitution measures that would likely be required to participate in a decommissioning project.
- **Homeowners without mortgage housing costs that are greater than 50% of their household income:** The assumption relative to this variable mirrors that of the previous, except as applied to homeowners who may be similarly burdened by non-mortgage related housing costs.

- **Renter housing costs greater than 50% of their household income:** The assumption relative to this variable mirrors that of the previous, except as applied to renters who may be similarly burdened by housing costs. (NOTE: This variable somewhat overlaps with the median gross rent as a percentage of household income, introduced previously. However, the research team observed that renters are not the principal agents responsible making property modification decisions. Thus, the team determined that it would be appropriate to include both variables in this sub-index as a way of amplifying these concerns relative to census tracts with larger populations of housing cost burdened renter households that are considered as having a lower measure of financial stability relative to the potential needs of decommissioning project participation.)
- **Percent of total housing units with gas heating equipment:** The assumption relative to this variable is that census tracts possessing a larger number of total housing units with gas heating equipment should be considered more dependent upon gas service and thus, less suitable for the immediate siting of gas decommissioning projects.
- **SF & MF residential parcel median annual gas consumption as a percentage of total site energy use:** The assumption relative to these variables is that census tracts with SF and MF residential parcels whose gas consumption represents a higher proportion of total site energy use are more dependent upon gas service and would likely encounter greater challenges in terms of hosting decommissioning projects. (Note: The research team observed that this ratio could be skewed if properties had unusually low levels of metered electricity consumption totals for one reason or another. Thus, the team included the following set of metrics representing the relative magnitude of the consumption of each fuel type, such that they can independently feed into the sub-index.)
- **SF & MF residential parcel median annual gas consumption in therms:** The assumption relative to these variables is that census tracts with SF and MF residential parcels that have higher median annual gas consumption totals are more dependent upon gas service.
- **SF & MF residential parcel median annual gas consumption per square foot of built area:** The assumption relative to these variables is that census tracts with SF and MF residential parcels that have higher median gas consumption totals per square foot are more dependent upon gas service.
- **SF & MF residential parcel median annual electricity consumption in kilowatt-hours:** The assumption relative to these variables is that census tracts with SF and MF residential parcels that have higher median annual electricity consumption totals are less dependent upon gas service.
- **SF & MF residential parcel median annual electricity consumption per square foot of built area:** The assumption relative to these variables is that census tracts

with SF and MF residential parcels that have higher median electricity consumption totals per square foot are less dependent upon gas service.

- **SF & MF residential total annual electricity consumption in kilowatt-hours:** The assumption relative to these variables is that census tracts with SF and MF residential parcels that have higher total annual electricity consumption levels are less dependent upon gas service.
- **SF & MF residential total annual gas consumption in therms:** The assumption relative to these variables is that census tracts with SF and MF residential parcels that have higher total annual electricity consumption levels are more dependent upon gas service.



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APPENDIX C: Weighting Coefficients – Detailed Tables

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APPENDIX C:

Weighting Coefficients – Detailed Tables

Table C-1: Weighting Coefficients for Commercial Sectors

End-Use Category	Weight	Justification	Sources
Space Heating & Cooling	1	Comparable heating technology such as mini split heat pumps and ducted heat pumps are readily available. Costs can be marginally higher for this equipment. Output is the same and can also compensate for cooling technology. There are no restricted industry norms or standard practices. Contractors are offering this, and state policy offers incentives to contractors and business owners.	California Energy Codes and Standards Cost-Effectiveness Studies 2022 Nonresidential New Construction and Existing Building Reports https://opiniondynamics.com/wp-content/uploads/2022/06/OD-CPUC-Heat-Pump-Market-Study-Report-f.pdf
Water Heating	1	Widely available electric-based technology alternatives. Heat pumps can be used for low-temperature water applications, while resistance-based systems can be used for higher temperature water requirements.	California Energy Codes and Standards Cost-Effectiveness Studies 2022 Nonresidential New Construction and Existing Building Reports https://www.energy.ca.gov/publications/2021/demonstration-high-efficiency-commercial-cooking-equipment-and-kitchen

End-Use Category	Weight	Justification	Sources
Cooking	2	Commercially ready, offered by contractors, rebates available, and offered in stores. Though the cost of these appliances is significantly higher than natural gas cooking appliances. Industry norms lean towards using natural gas cooking appliances due to perception that they are 'better for cooking' and have more heat control, though manufacturers claim they have comparative performance to gas power cooking equipment.	California Energy Codes and Standards Cost-Effectiveness Studies 2022 Nonresidential New Construction and Existing Building Reports https://www.energy.ca.gov/publications/2021/demonstration-high-efficiency-commercial-cooking-equipment-and-kitchen California Foodservice Instant Rebates https://caenergywise.com/instant-rebates/
Miscellaneous	1	The equipment from four of the six "Miscellaneous" sub-categories are entirely electric by default due to the adaptability and mobility required by the industries in which they are most commonly used. Of the equipment in the remaining two sub-sectors, there are also commercially available electric alternatives for each, however industry norms, cost considerations, and concerns over efficiency are the primary roadblocks to complete electrification.	CEUS 2006 Appendix C https://www.energy.ca.gov/data-reports/surveys/california-commercial-end-use-survey/2006-california-commercial-end-use-survey

End-Use Category	Weight	Justification	Sources
Process	2	Though the equipment categorized under "Process" encompasses many industries, much of the equipment is known to be electrifiable, if not already electrified. Process natural gas usage outside of cooking equipment applies to only a small pool of industrial activities that are classified under the commercial sector. The cooking equipment already has commercial alternatives that are readily available, though, as mentioned above, industry norms lean toward using natural gas for certain processes. Most of the remaining equipment borders on industrial process equipment that has been augmented or adapted to operate in mostly electrified commercial office settings. However, there are remaining pieces of equipment that are not currently electrifiable, given the energy intensity of said equipment.	CEUS 2006 Appendix C https://www.energy.ca.gov/data-reports/surveys/california-commercial-end-use-survey/2006-california-commercial-end-use-survey

End-Use Category	Weight	Justification	Sources
CHP & Cogeneration Process	2	Combined heat and power (CHP) or cogeneration processes produces electricity and thermal energy generally from natural gas. Alternatives to a CHP plant running off natural gas is an all-electric central heating and cooling plant or potentially replacing the fuel with hydrogen or biofuels as they become more available. The all-electric option requires fundamentally changing the source of electricity for the facility and has consequences to the thermal energy products, but it is generally possible to implement. On-site renewable energy and storage is another option. Hydrogen fuel is not yet available at the scale needed and there are many remaining questions about the distribution of the fuel.	UC Berkeley Goes All-Electric https://alumni.berkeley.edu/california-magazine/2023-spring-summer/berkeley-goes-all-electric-as-part-of-ambitious-clean-energy-campus-plan/
Conventional Boiler Use	1	Electric boilers are cheaper than combustion boilers and more efficient. However, higher cost of electricity than gas overcomes the upfront savings and efficiency gains. The primary barrier to electrification for boilers is the cost.	Electrification of Boilers in U.S. Manufacturing https://www.globalefficiencyintel.com/electrification-of-boilers-in-us-manufacturing

End-Use Category	Weight	Justification	Sources
Conventional Electricity Generation	1	In conventional power plants that combust natural gas, steam is generated and fed to a turbine, which converts the heat energy to mechanical energy that in turn is converted to electrical energy. Manufacturing facilities would either need to purchase electricity from their utility or develop renewable energy resources, which poses temporal limitations and different land needs.	How Battery Energy Storage Displaces and Replaces Conventional Generation https://www.sandia.gov/ess-ssl/wp-content/uploads/2018/08/2017_EESAT_Proceeding_Jacobs.pdf
Facility HVAC	1	Electric HVAC systems are readily available. Upfront costs are higher for electric systems but come with significant efficiency gains.	Commercial HVAC Retrofits Can Electrify the Bottom Line https://www.achrnews.com/articles/147247-commercial-hvac-retrofits-can-electrify-the-bottom-line
Machine Drive	1	This includes motors, pumps, etc. associated with manufacturing process. Electric motors are widely used in the industrial sector. In total, electricity powers about 89% of motors in manufacturing.	Improving Motor and Drive System Performance Sourcebook https://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/motor.pdf Electricity use by machine drives varies significantly by manufacturing industry https://www.eia.gov/todayinenergy/detail.php?id=13431 Growing role of electrical machines and drives in electrification https://ieeexplore.ieee.org/document/7732552
Onsite Transportation	1	Battery electric forklifts and other forms of onsite transportation have been used commercially for decades.	https://dof.ca.gov/wp-content/uploads/sites/352/2023/04/ZE-Forklift-SRIA-to-DOF.pdf

End-Use Category	Weight	Justification	Sources
Other Facility Support	1	In the MECS survey, the examples of "Other Facility Support" include cooking, water heating, and office equipment, all of which have readily available electric alternatives.	2022 Manufacturing Energy Consumption Survey https://www.eia.gov/survey/form/eia_846/proposed/2022/form.pdf
Other Process Use	3	Technologies to electrify process non-heating uses of gas are still being developed and have not achieved a high readiness state at this time.	Electrification in industrials https://www.deloitte.com/us/en/insights/industry/power-and-utilities/electrification-in-industrials.html Electrification of Buildings and Industry in the United States https://eta-publications.lbl.gov/sites/default/files/electrification_of_buildings_and_industry_final_0.pdf Process Cooling and HVAC https://betterbuildingsolutioncenter.energy.gov/better-plants/process-cooling-and-hvac
Process Cooling and Refrigeration	1	Electric heat-pump based cooling technologies are readily available for a wide variety of Process Cooling and Refrigeration applications.	Electric Chillers https://esource.bizenergyadvisor.com/article/electric-chillers
Process Heating	3	Technologies to electrify Process Heating uses of gas are still being developed and have not achieved a high readiness state at this time.	Finding Efficiencies in Process Heat https://www.energy.gov/eere/iedo/decarbonizing-process-heat https://eta-publications.lbl.gov/sites/default/files/electrification_of_buildings_and_industry_final_0.pdf https://eta-publications.lbl.gov/sites/default/files/electrification_of_buildings_and_industry_final_0.pdf

End-Use Category	Weight	Justification	Sources
Electro-Chemical Processes	3	There are studies citing the transition for gas as feedstock and energy source to recycled hydrogen for Electric-Chemical Processing. However, the technologies are still very early in the stage of development and have not been implemented. Additionally, implementation is contingent on the wide availability of hydrogen.	Emerging opportunities for electrochemical processing to enable sustainable chemical manufacturing https://www.sciencedirect.com/science/article/pii/S2211339817300977



California
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ENERGY RESEARCH AND DEVELOPMENT DIVISION

APPENDIX D: CBOs and Stakeholder Attendee Lists

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APPENDIX D:

CBOs and Stakeholder Attendee Lists

Community-Based Organizations

- Latino Leadership Council
- Renaissance Entrepreneurship Center
- Community Agency for Resources, Advocacy and Services (CARAS)
- Climate First: replacing Oil & Gas (CFROG)
- Rising Sun
- Breathe California
- Communities for a Better Environment (CBE)
- Acterra
- Rise South City
- CRC Communities
- Tule River
- Hoopa
- Inter-tribal Council
- Blue Lake Rancheria
- Desert Cahuilla.
- Groundwork San Diego
- Building Electrification Institute (BEI) Cities
- East LA Community Corporation
- Nature for All
- Humboldt Permaculture Guild (HPG)
- Little Manila Rising
- Restore the Delta
- Catholic Charities Environmental Justice Program
- California Environmental Justice Alliance (CEJA)
- Environmental Justice Coalition for Water
- Central Valley Air Quality Coalition

- Greenlining Institute
- Self Help Enterprises (SHE)
- Leadership Counsel for Justice and Accountability
- Communities for a Better Environment (CBEAL)
- Literacy for Environmental Justice
- Bright Line Defense
- Citizen Air Monitoring Network
- East Yard Communities for Environmental Justice
- La Jolla Band of Luiseno Indians
- PSE Health Energy

Workshop One – October 20, 2023

Attendees included:

- Balance2thrive
- Ballona Wetlands Institute
- BHHS Drysdale Properties
- City of Fresno
- Climate First: Replacing Oil & Gas
- Cool Davis
- East Side Union High School District
- Energy Graduate Group
- Food & Water Watch
- Let's Green CA! Romero Institute
- Local Clean Energy Alliance
- PSE Health Energy
- PSR SF Bay
- RMI
- Sierra Club
- The Energy Coalition
- Westside Clean Air Coalition
- Working Partnership USA

Workshop Two – October 2, 2024

Participants joined the event representing the following regions and organizations:

- 350ContraCostaAction (Contra Costa County)
- 359 CONTRA COSTA (Contra Costa County)
- Alviso Neighborhood Group (Alviso, Santa Clara County)
- Blue Lake Rancheria Tribe (Humboldt County)
- CBE – Communities for a Better Environment (Richmond)
- CFROG – Climate First: Replacing Oil & Gas (Oxnard, Ventura County)
- CalNRG (Ventura County)
- Central California Asthma Collaborative (Fresno, Central Valley)
- Climate Resilient Communities (San Mateo County)
- Community Environmental Council (Santa Barbara County)
- Cool Davis (Davis, Yolo County)
- County of Ventura (Ventura County)
- EVA Academy (Santa Paula, Ventura County)
- Justice for All Ventura (Ventura, Ventura County)
- Menlo Spark (Menlo Park, San Mateo County)
- PSE Healthy Energy (Oakland, Alameda County)
- RCB Consulting (Richmond, Contra Costa County)
- RMI (Oakland, Alameda County)
- Renaissance Entrepreneurship Center (San Francisco, San Francisco County)
- Rise South City (South San Francisco, San Mateo County)
- Rising Sun Center for Opportunity (Stockton, San Joaquin County)
- Santa Barbara Clean Energy (Santa Barbara, Santa Barbara County)
- Self-Help Enterprises (Visalia, Tulare County)
- The Energy Coalition (Irvine, Orange County)

Public Webinar – October 8, 2025

Participants joined the event representing the following organizations:

- Blue Lake Rancheria Tribe
- Building Decarbonization Coalition

- California Public Utilities Commission
- City of Albany, California
- Construction Trades Workforce Initiative
- E3
- Little Manila Rising
- PG&E
- San Mateo County, California
- SoCalGas