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THE ROLE OF CLEAN FUELS
AND GAS INFRASTRUCTURE IN ACHIEVING CALIFORNIA'S NET ZERO CLIMATE GOAL

Summary Report

SoCalGas™

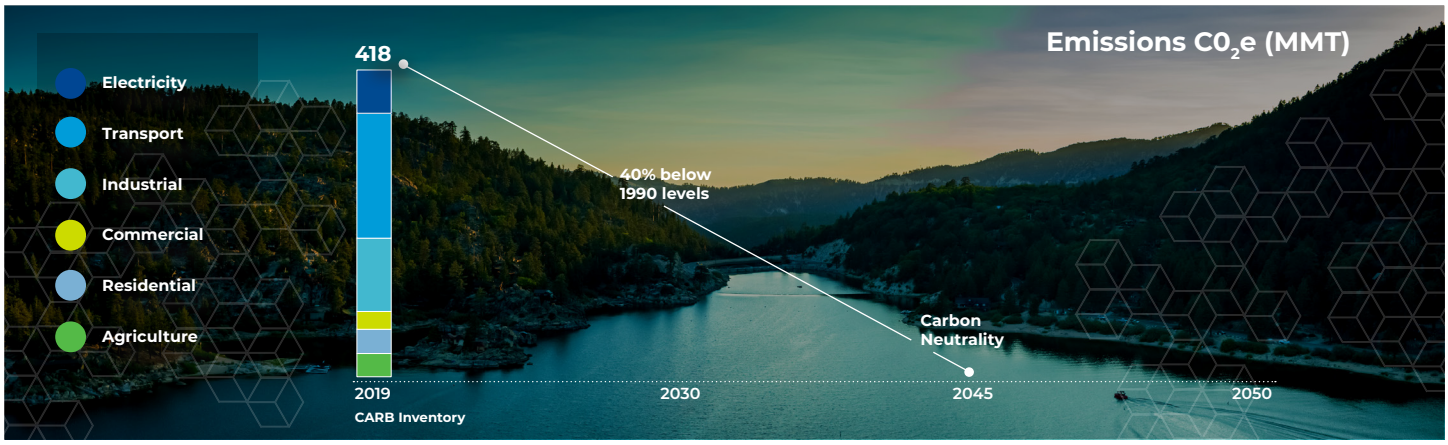
EXECUTIVE SUMMARY

Climate change and the imperative to reduce GHG emissions are driving a transformation of our nation's entire energy system.

Across the United States, electric and gas utilities are re-envisioning how they deliver the energy Americans need. SoCalGas aspires to achieve net zero emissions in everything we do by 2045 and we are decarbonizing our business to lead in California's energy transition.

The question facing California is: What are the best options for reaching carbon neutrality? To answer that question, SoCalGas undertook an analysis to find the best approaches for California to achieve clean, reliable, and affordable energy to ultimately support a carbon neutral economy.

California Emissions and Targets



Our analysis examines the complexity of getting to net zero in California and offers detailed solutions, including the clean fuels infrastructure to support decarbonization.

Clean fuels are gases like clean hydrogen[1], renewable natural gas (also referred to as biogas and RNG), synthetic natural gas (also referred to as syngas and SNG), and biofuels, the production and combustion of which can be carbon-neutral or even carbon negative.

The study asks three key questions to evaluate California's options to reach net zero:

1. What options do we have for reaching carbon neutrality, and what factors inform the best approaches?
2. What role do clean fuels have to play, and how can complementing technologies like fuel cells and carbon capture and sequestration add value?
3. What would a clean fuels network look like?

1. References to and use of the word "hydrogen" in this study refer to net-zero emissions hydrogen; green or blue whereby carbon emissions are captured and stored.

EXECUTIVE SUMMARY

The analysis examines four scenarios for reaching net zero:

Resilient Electrification is significant electrification of buildings and vehicles supported by low level of clean fuels, with carbon management

High Clean Fuels is moderate electrification of buildings and vehicles supported by a high level of clean fuels, but no carbon management

High Carbon Sequestration is moderate electrification of buildings supported by a high level of carbon management but a low level of clean fuels

No Clean Fuels is significant electrification of buildings and vehicles with no support from either clean fuels or carbon management

The scenarios are evaluated against five criteria: 1) system reliability and resiliency, 2) as a solution for hard-to-abate sectors, 3) customer conversion challenges, 4) technical maturity of technology, and 5) affordability.

"Hard-to-abate sectors" of the economy, which include heavy-duty trucking and industry, are areas in which electrification is challenged to meet sector needs. The study proposes solutions for these sectors, and these solutions complement current state climate and energy policies to reduce emissions.

This analysis employs detailed modeling similar to that done to support other California decarbonization studies by the California Air Resources Board (CARB) and the California Energy Commission (CEC). The study's results were independently verified by experts from two leading California research institutions (UC Irvine and UC Davis), as well as Columbia University.

Key Takeaways

- Combining the strengths of renewable electricity from solar and wind (clean electrons) with clean hydrogen, RNG, syngas, and biofuels (clean molecules) is the most affordable, resilient, and technologically proven path to carbon neutrality
- To meet customer needs, a clean fuels network that leverages gas infrastructure is an essential part of California meeting its climate goals
- Leveraging the existing gas system to deliver clean fuels and manage carbon allows California to achieve net zero goals more affordably and with less risk than other options
- Looking ahead, stakeholders must act faster and with greater collaboration to expand and accelerate the deployment of decarbonization tools, including the clean fuels initiatives already underway

ALL SCENARIOS MEET NET ZERO

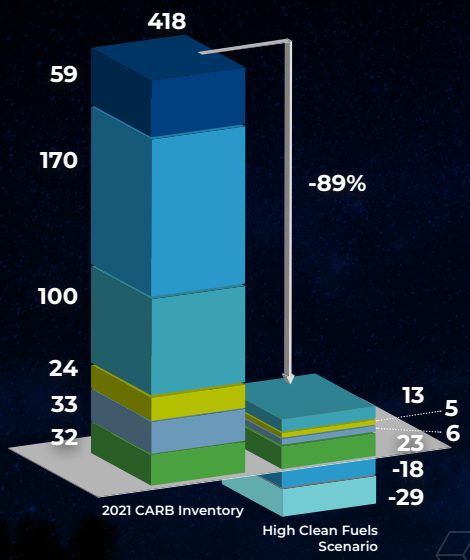
How Each Scenario Reaches Net Zero

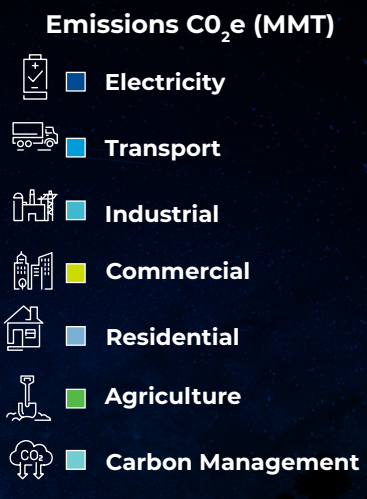
Key Assumptions		Resilient Electrification	High Clean Fuels	High Carbon Sequestration	No Fuels Network
Clean electricity and economy-wide GHG policy		SB100 and B-55-18; Carbon Neutrality by 2045			
Building electrification		100% sales of gas appliances electrified by 2035	50% sales of gas appliances electrified by 2035		100% sales of gas appliances electrified by 2035
H2 pipeline blending cap (by Volume)		5%	20%	No cap	N/A: No remaining pipelines
Transportation sales by 2035	Light Duty	BEV: 85% FCEV: 15%			
	Medium Duty	BEV: 90% FCEV: 10%	BEV: 50% FCEV: 50%		BEV: 90% FCEV: 10%
	Heavy Duty	Short-haul and transit buses BEV: 100% FCEV: 0% Long Haul: BEV: 50% FCEV 50%	Short-haul and transit buses BEV: 50% FCEV: 50% Long Haul: BEV: 0% FCEV 100%		Short-haul and transit buses BEV: 100% FCEV: 0% Long Haul: BEV: 50% FCEV 50%
Carbon sequestration allowed[1]		YES	NO	YES	NO

BEV: Battery Electric Vehicle **FCEV:** Fuel Cell Electric Vehicle **SB100:** The law passed by the California Legislature and signed by then-Governor Brown that established a landmark policy requiring renewable energy and zero-carbon resources to supply 100 percent of electric retail sales to end-use customers by 2045. **B-55-18:** An Executive Order issued by former Governor Brown that established the statewide goal to "achieve carbon neutrality as soon as possible, and no later than 2045, and maintain and achieve negative emissions thereafter."
1. Though carbon sequestration is disallowed in some scenarios, some form of "carbon management" appears in all scenarios; this includes carbon that is captured and utilized or sequestered as well as carbon used in products (asphalt, plastics) and carbon offset through bunkering of emissions from other sectors.

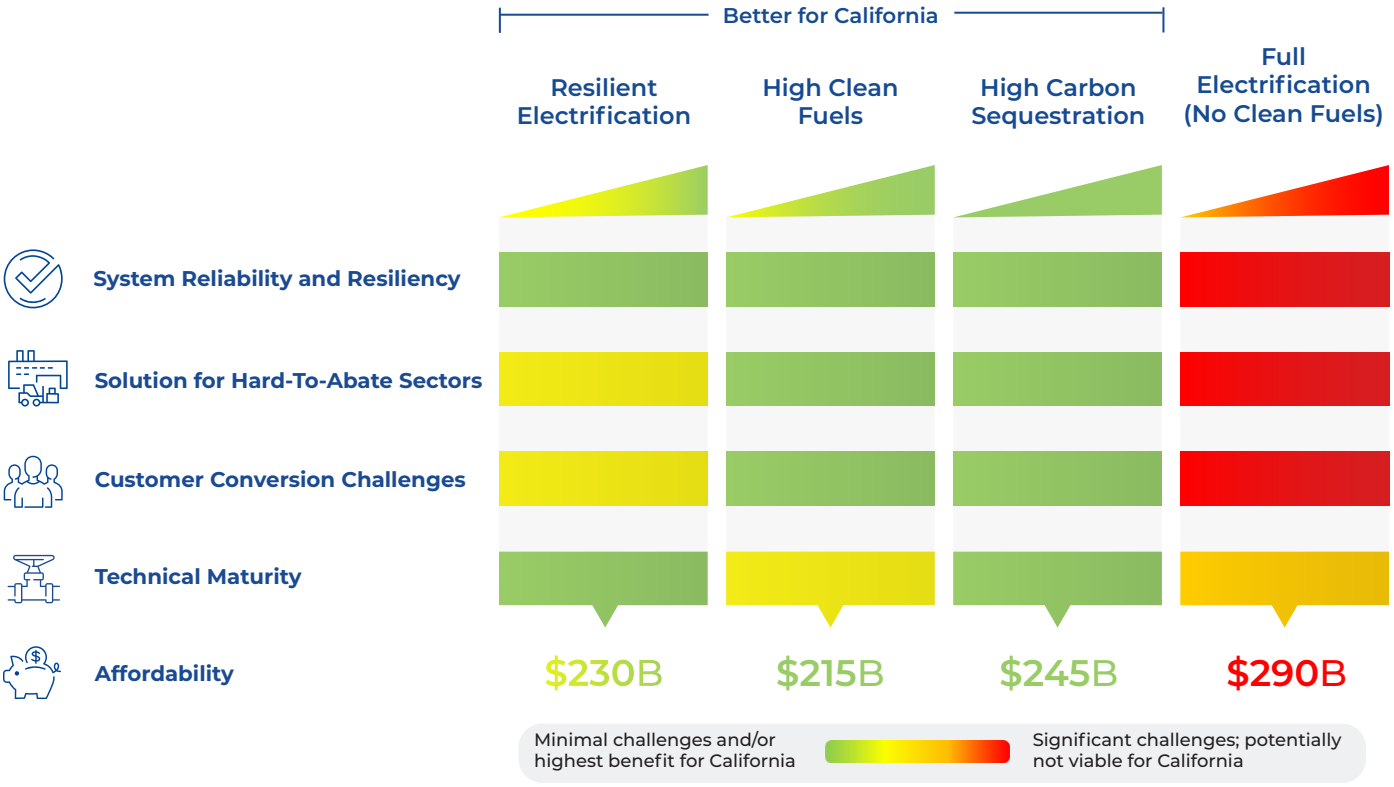
The analysis employs ambitious electrification specifications for vehicles and buildings but relatively conservative parameters for clean fuels as expressed in % of hydrogen blending and usage of fuel cell vehicles.

Modeled 2045 California Emissions Reductions by Segment
High Clean Fuels Scenario





Study Results



System Reliability and Resiliency

Reliability refers to the system operating under normal conditions. Resiliency is the system's ability to bounce back quickly and minimize system outages from unforeseen events such as wildfires, high winds, or unexpected and significant constraints on energy supply.

All scenarios analyzed assume high levels of building electrification from 50% to 90% by 2045. The **High Clean Fuels** and **High Carbon Sequestration** scenarios assume that by 2045 between 65% to 70% of customers keep using fuels as well as the electric delivery system, as they do today.

In the **No Fuels Network** scenario all customers rely solely on electric power. In this scenario, a power supply issue with the electric system – either in generation, transmission, or distribution – could cause all end-users to be without energy. This option locks in considerably less resiliency than today's system.

Solutions for Hard-to-Abate Sectors

In all scenarios, hard-to-abate sectors vital to California's economy – industry, heavy-duty transportation (trucks, planes, ships), and dispatchable electric generation – require clean fuels and/or carbon capture, utilization and storage (CCUS) to most affordably achieve decarbonization.

The **Resilient Electrification, High Clean Fuels,** and **High Carbon Sequestration** scenarios involve continued investment in the existing gas infrastructure and building out infrastructure to deliver decarbonized electrons and decarbonized molecules to customers.

In the **No Fuels Network** scenario, gas infrastructure is decommissioned, the vast majority of energy demand is electrified (~90%), and customers who rely on gases are assumed to produce and store on site or truck in fuel.

Customer Conversion Challenges

Large scale energy transitions will require changes to many customers' homes and businesses – insulation, energy efficient appliances, and fuel-switching from natural gas appliances to electric and/or hydrogen equipment. Some changes could be driven by customer choice, some by policy. Managing this conversion is one of the most substantial implementation challenges associated with achieving net zero.

The **Resilient Electrification** scenario assumes 100% of residential and commercial appliance and equipment sales are electric by 2035 (resulting in approximately 95% of buildings relying on electric appliances for heat and hot water in 2050), compared to 50% in the **High Clean Fuels** and **High Carbon Sequestration** scenarios. Achieving full customer conversion at such scale presents significant cost, equity, and feasibility challenges. SoCalGas is actively working with stakeholders to explore and address them.

Similarly, in the **No Fuels Network** scenario all residential, commercial, and industrial would convert all appliances and equipment to electric or truck in fuel, without clean fuel as an alternative or back-up. 100% electrification is therefore expressed in this analysis to be the most challenging scenario. A balance of clean fuels replacing natural gas combined with electrification could prove easier to implement for customers.

CRITERIA FOR EVALUATION

Technical Maturity

All technologies considered are either currently in development or have been deployed, though some are in nascent stages.

The **High Clean Fuels** scenario presumes 20% blending in pipelines can be achieved in existing California infrastructure with relatively low additional investment, and that hydrogen can be extracted from blended pipelines to serve dedicated end-uses like refueling stations.

Resilient Electrification and **High Carbon Sequestration** have a more favorable rating on technical maturity, as uncertainty around their feasibility is lower. Increased electrification in urban areas and installation of fuel cells at large scale, though challenging, are more technologically mature.

The **No Fuels Network** scenario assumes no thermal generation and relies on long-duration battery storage to meet system needs during power supply inadequacy events due to variability of renewable generation.

Finally, the analysis shows that a diverse set of decarbonization levers reduces the risks of over-dependence on any one technology.

Affordability

The three scenarios using a clean fuels network are more affordable than a **No Fuels Network** approach. For supporting a high-renewables system, thermal generation and clean molecules are the lowest-cost and most technologically feasible approach.

Without a clean fuels network, a significantly larger and more expensive buildout of renewables and storage is needed. Alternative forms of long duration storage would need to scale up from a nascent level and rapidly reach low price targets to avoid a high-cost burden.

Thus, decarbonizing the energy system with a clean fuels network is significantly more affordable as compared to other scenarios.

Getting To Net Zero
Clean Fuels and Electrification

The scenarios that advance decarbonization most successfully combine the strengths of renewable clean fuels and electricity. Moreover, a clean fuels network supports renewable wind and solar energy in several ways:

Supporting Electricity Decarbonization

As more solar and wind are integrated onto the grid, and as more end uses are electrified, a clean fuels network supports the reliability of the electric grid by providing indispensable, flexible, and dispatchable power at times when renewables are intermittent.

Providing Decarbonized Energy for Hard-to-Abate Sectors

Clean fuels will be essential to decarbonizing hard-to-abate sectors of the economy like heavy-duty transportation and industrial activities, which currently account for ~20% of California's greenhouse gas emissions.

Preserving Resiliency

Underground gas networks are less susceptible to extreme weather, adding resiliency to the system. A clean fuels network can enhance the electric network by providing zero emissions fuels to power generation facilities.

Providing Carbon Management Infrastructure

The best-performing scenarios employ carbon capture and utilization, sequestration, or both. A clean fuels network's pipelines could play a vital role in carbon management[1].

Diversification Lowers Risk

A diverse set of decarbonization levers reduces the risk of over-dependence on any one technology. Scaling multiple technologies and decarbonization tools de-risks California's decarbonization pathways by offering maximum flexibility for bringing on-line technological advancements.

Lowering Costs

The analysis shows a clean fuels network is worth between $45-$75 billion in savings in terms of the investment needed to achieve net zero, as compared to spending needed if the existing fuels network were fully decommissioned.

1. 2018 CARB Invetory

EQUITY & AFFORDABILITY

Decarbonizing California will affect different end-users in distinct ways – changes in the origin and type of energy they use, the amounts consumed, the prices paid, and when and how flexibly customers utilize energy.

Many homes and businesses are expected to electrify. Some customers may see no changes to their buildings as the electrons and molecules powering their appliances and equipment are decarbonized further upstream, or their emissions are offset by carbon management. Other customers may see significant changes to the equipment in their homes or businesses.

Analyses of the impacts on low-income customers, bills and share of costs, and ways to mitigate those impacts are needed. To achieve an equitable energy transition, elements of cost allocation and rate design must be evaluated as pathways are developed and materialize.

To make the energy transition more affordable, utilities and other stakeholders must work together to achieve equitable customer transitions. To cost-effectively decarbonize, cost allocation policies and rate design structures should evolve to complement a changing commercial environment. Utility investment and access to capital markets, combined with the ability to employ cost-sharing mechanisms to protect disadvantaged customers, could create levers to help manage the energy transition.

ACCELERATING DECARBONIZATION WITH CLEAN FUELS

The models indicate a need to urgently accelerate clean fuels technologies to ramp up and achieve economies of scale. Putting a clean fuels network in place in time to meet the levels of clean fuels called for means rapidly scaling up activity today.

Regulated utilities can play a unique role in scaling new technologies to bring a clean fuels network into the energy system. Utilities such as SoCalGas can use existing assets, expertise, and customer relationships to help drive a rapid energy transition.

Utilities also have the ability to allocate costs across many users and access long-term capital to reduce the cost of new assets needing to be built.

Looking ahead, California must act quickly and with broad collaboration to expand and accelerate clean fuels initiatives in three vital ways:

1. **Invest in the safety and reliability of existing infrastructure to transport lower carbon fuels to accelerate the energy transition, while maintaining resiliency and affordability.**

2. **Incorporate increasing levels of clean fuels into our system, delivering to customers clean, renewable and/or carbon neutral fuels such as RNG, clean hydrogen, and syngas.**

3. **Build essential new infrastructure for breakthrough solutions such as delivering pure hydrogen to customers, managing carbon through carbon transportation/usage/storage, and support development of distributed energy resources by investing in microgrids and fuel cells.**

A VISION FOR A CLEAN FUELS NETWORK

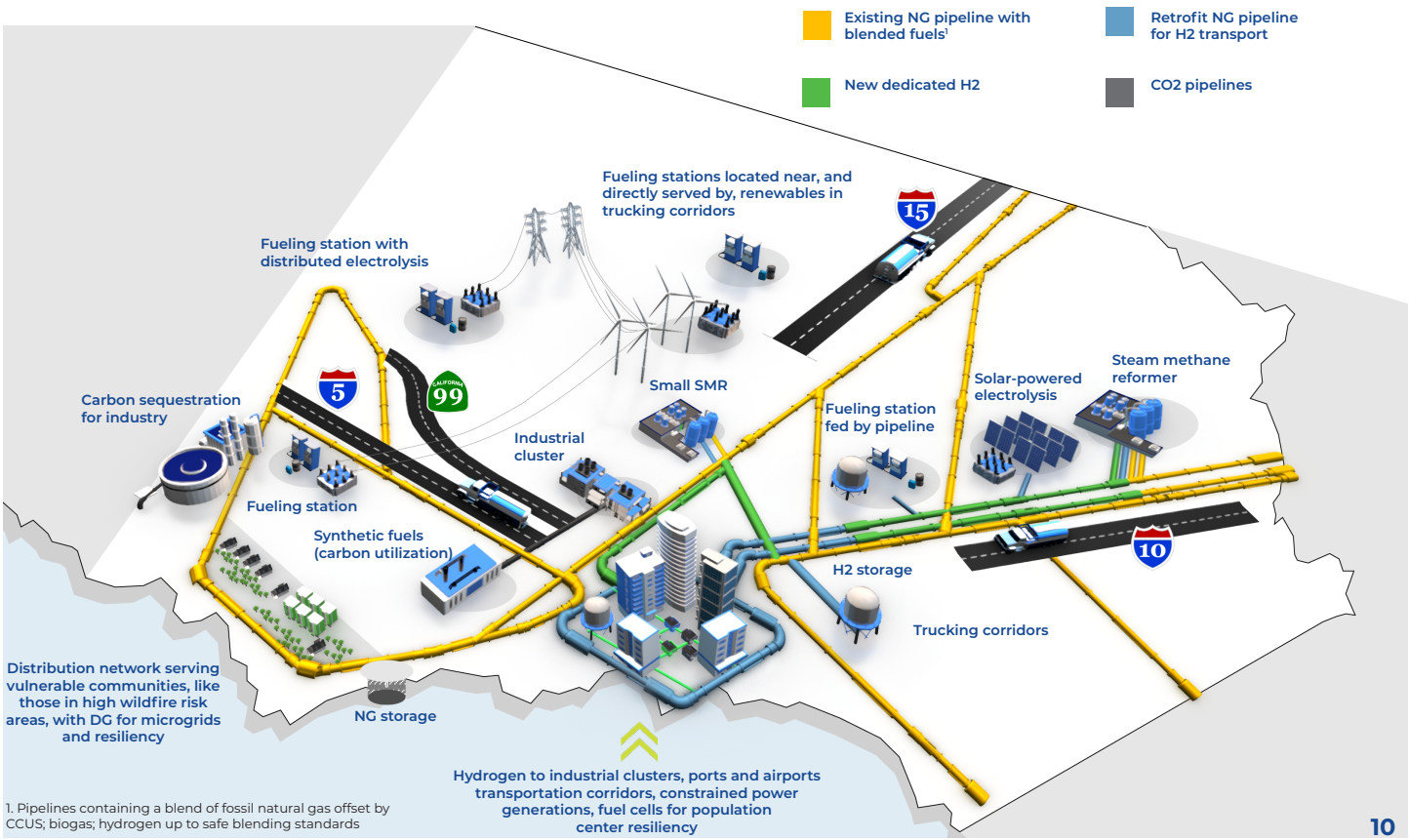
A clean fuels network facilitates the production, transmission, distribution, consumption, and storage of clean fuels including hydrogen, biogas, synthetic natural gas (SNG), biofuels and synthetic fuels. Certain clean fuels such as biogas and syngas are "drop-in fuels" requiring no change in the current infrastructure to support their transport. Because direct decarbonization of fossil fuels involves carbon capture, this network also assists with transport and sequestration or utilization of carbon dioxide.

Transporting hydrogen can take significant advantage of leveraging the existing system, but it will require investment to achieve hydrogen readiness, adequate hydrogen storage, and delivery of significant hydrogen volumes to new use cases (e.g., heavy-duty, long-haul vehicles, thermal generation).

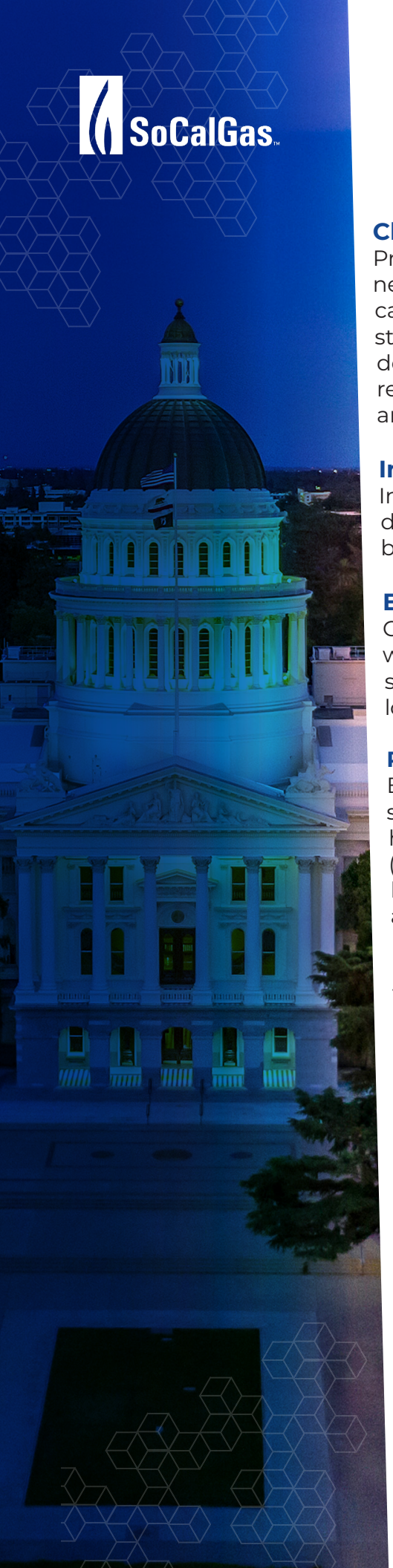
Hydrogen infrastructure can be scaled incrementally, starting with geographically concentrated clusters of demand where hydrogen is more cost-effective in the near-term.

For example, the Ports of Los Angeles and Long Beach could serve as a near-term source of demand for hydrogen for heavy-duty trucks, forklifts, and potentially for marine fueling, as well as for industrial needs near the ports. Additionally, Los Angeles Department of Water and Power (LADWP) has expressed the need to include hydrogen in its 100% renewable electricity plans.

Illustrative Vision Of A Clean Fuels Network



1. Pipelines containing a blend of fossil natural gas offset by CCUS; biogas; hydrogen up to safe blending standards



PUBLIC POLICIES TO SUPPORT CLEAN FUELS

Clean Fuels Procurement Standard:

Procuring and blending RNG, hydrogen, and other carbon neutral/ negative fuels into the clean fuels network is essential for lowering the carbon intensity of fuels. A procurement standard like the renewable standard used by electric utilities would accelerate clean fuels deployment. The CPUC recently issued a staff report (SB 1440 Report) recommending a renewable gas procurement program for residential and small commercial customers.

Investing in Infrastructure:

Investments to modernize the gas infrastructure for hydrogen and for distributing all clean fuels are vital to realizing the cost-savings offered by a clean fuels network.

Energy Efficiency Solutions:

Customer incentives to increase energy efficiency (furnace replacement, window/insulation upgrades, etc.) and demand response programs like smart thermostats that reduce throughput are powerful levers for lowering emissions while also economical for customers.

Research, Development and Demonstration (RD&D):

Breakthrough technologies are essential to developing decarbonization solutions and scaling them quickly. Accelerated RD&D for clean hydrogen production, hydrogen fuel cells, distributed energy resources (including hydrogen hubs), industrial hydrogen clusters, national hydrogen blending standards and carbon management will advance a clean fuels network.

Carbon Capture, Utilization, and Sequestration (CCUS):

The International Panel on Climate Change (IPCC), the International Energy Agency, and other global climate experts agree that carbon capture, utilization, and sequestration is needed alongside – not instead of – other mitigation tools to meet Paris Climate Agreement's targets. Gas utility infrastructure and expertise can contribute greatly to CCUS deployment.

Modern Rate Structures:

An updated rate structure is needed to modify the approach to cost recovery allocation to account for the change in customer usage of the clean fuels network over time (e.g., declining residential and commercial volumes and increasing reliance of power plants and large industrial customers on a reliable and resilient clean fuels network for high-heat technical processes that are hard to electrify.)

THE GOAL TO 2045

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FORWARD-LOOKING STATEMENTS

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