Recommendations to Advance Forest-Derived Renewable Natural Gas in California

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Executive Summary

Markets for renewable natural gas from forest biomass are emerging in California. Senate Bill 155, approved by Governor Newsom on September 23, 2021, makes available $50,000,000 in the 2022–23 fiscal year to the Department of Conservation, in coordination with the State Air Resources Board and the Energy Commission, for pilot projects to create carbon-negative fuels from materials resulting from forest vegetation management. In conjunction, Southern California Gas Company (SoCalGas) and Pacific Gas and Electric Company (PG&E) have each filed an application to the California Public Utilities Commission (CPUC) proposing one woody biomass gasification project focused on conversion of woody biomass to biomethane, or Renewable Natural Gas (RNG). These pilot projects, currently managed by Southern California Gas Company (SoCalGas) and Pacific Gas and Electric Company (PG&E) are meant to demonstrate forest derived RNG from forest biomass in California.

This document presents recommendations for the California Public Utilities Commission (CPUC) and other state agencies on Renewable Natural Gas (RNG) derived from forest biomass. To generate these recommendations, we: 1) conducted a geospatial analysis of existing biomass power plants and evaluated their possible retrofit for RNG production, 2) conducted interviews with bioenergy project developers to gain insights on current practices, challenges and areas of opportunity regarding the procurement of RNG from forest biomass, and 3) derived potential policy scenarios in which RNG becomes economically viable, through a discounted cashflow model and policy scenario analysis.

From these methodologies we learned that: 1) it is possible to ramp up the state annual energy production by 4.5 GJ per year and the woody biomass utilization volume by 1 million BDT per year by retrofitting for RNG production from 10 currently closed or idled biomass power plants, 2) that there is technology, trust, and willingness in the bioenergy community to produce RNG from forest biomass, but it is not financially viable to do so in the present political and economic environment, 3) that it is possible to support further forest biomass to RNG pathways through policy changes, state subsidies and alternative RNG end uses.

The main recommendations produced from this work were to enable the repurposing of existing infrastructure for a low carbon future; to embrace RNG as a time-limited climate solution; to enhance the economic viability of RNG projects by modifying the existing CPUC policy to use RNG as a transportation fuel; and to ensure the demand for forest-derived biofuels as alternatives to RNG.

1. Introduction

Among the largest economies in the world (Winkler, 2022), California has one of the most ambitious agendas for deep decarbonization and climate action. California's current *Scoping Plan for Achieving Carbon Neutrality* aims to cut greenhouse emissions (GHG) by 85%, cut oil usage by 94% and cutting air pollution by 71% by 2045, all whilst creating 4 million of new jobs and saving the state $200 billion in health cost due to air pollution (CA Gov, 2022). As part of the state's effort towards its decarbonization goals, Senate Bill (SB) 1440 was approved in September 2019 by Governor Newsom. The purpose of the bill was to push forward pathways for procurement of renewable natural gas (RNG) from organic waste and forest biomass.

As recently noted in the proposed state Wood Utilization Strategy, there is a need for a market for low-value wood and biomass. Pile burning increases risk of wildfires and emissions are a threat to air quality and climate change goals (California Wildfire & Forest Resilience Task Force , 2023). For this reason, the California Wildfire and Forest Resilience Task Force developed a Draft Wood Utilization Plan with the goal of achieving a 1,000,000-acre treatment target through the growth of California's wood processing capacity. In addition to developing new markets for durable wood products and advanced biofuels, achieving this goal would support related relevant sustainability goals for California such as the United States Department of Agriculture 10-year strategy to confront the wildfire crisis (USDA, 2023), the California Air Resources Board 2022 scoping plan for achieving carbon neutrality (CARB, 2023), and the Community Economic Resilience Fund's agenda (CERF, 2022). CARB estimates 5 million bone dry tons (BDT) of biomass residue can be available annually from one million acres of forest health and wildfire resilience treatments (California Wildfire & Forest Resilience Task Force , 2023). Therefore, it is pertinent to support forest-biomass-to-fuels pathways as one way to push forward the decarbonization journey of the state and making use of residues from California's forests.

Upon appropriation by the Legislature, SB 155 made available $50,000,000 in the 2022–23 fiscal year to the Department of Conservation, in coordination with the State Air Resources Board and the Energy Commission, for pilot projects to create carbon-negative fuels from materials resulting from forest vegetation management.. As part of SB 1440 implementation, the CPUC has also set a 2025 procurement goal target for organic waste diverted annually from landfills of eight million tons. By 2030, the Joint Utilities would be required to procure 72.8 billion cubic feet (Bcf) of biomethane annually, which is approximately 12.3 percent of total annual statewide gas IOU core customer consumption in 2020. In conjunction, Southern California Gas Company (SoCalGas) and Pacific Gas and Electric Company (PG&E) have each filed an application to the California Public Utilities Commission (CPUC) proposing one woody biomass gasification project focused on conversion of woody biomass to biomethane, or Renewable Natural Gas (RNG).

These pilot projects shall include the procurement of bio-Renewable Natural Gas (RNG) from forest, agricultural, and urban wood waste pyrolysis and gasification projects using methanation. Each utility may decide whether its pilot project will focus on forest or agricultural waste based on what best serves its interests and the interests of its customers. SoCalGas and PG&E shall coordinate such gasification projects and strategic placement with the pilot projects authorized for the Department of Conservation by Senate Bill 155. The project cost shall include pipeline extensions to the pilot facilities. Pipeline extensions should facilitate future potential extensions for additional projects and the pilots should propose methods for using carbon dioxide in carbon capture and storage or use projects rather than venting it to the atmosphere. Pilots proposed should test technologies that are capable of expansion and that have significant potential to increase the RNG supply in the long term. The pilots shall study and report fugitive methane, pollutant, and particulate matter emissions and emissions reduction or elimination methods in the gasification or pyrolysis process, the methanation process, and pipeline infrastructure. The utilities shall set aside $40 million from their 2022 Cap-and-Trade Program allowance auction proceeds to fund these pilot projects. The CPUC is currently considering PG&E and SoCalGas' proposals.

This document presents recommendations to the CPUC and state's Investor-owned utilities regarding procurement of biomethane from forest biomass. The recommendations, results and insights in this document are the product of the joint work with CPUC staff, emerging forest-to-fuels technology developers and state investor-owned utilities in developing these recommendations. This document contains the draft recommendations which will be presented in November 2023 to the Joint Institute for Wood Products Innovations (Institute) Advisory Council. Based on the Council's feedback, the final draft recommendations will be developed and presented to the Board of Forestry and Fire Protection (Board) in January 2024. The final ADA-compliant report will be presented to the Board on consent in March 2024.

2. Methodology

The recommendations presented in this document are derived from three approaches. First, a geospatial analysis of existing wood bioenergy facilities was done to identify potential candidates for conversion to RNG production. Based on their proximity to the current natural gas pipeline infrastructure and recoverable forest biomass, 18 facilities were selected for this analysis. Then, it was estimated what volume of biomass each of these facilities could treat in a year, the amount of energy they could produce and the cost of each facility's conversion for RNG production. These numbers were finally compared to the state's 2030 wood utilization targets presented on the state's Wood Utilization Strategy (California Wildfire & Forest Resilience Task Force , 2023).

Second, interviews were conducted with RNG and energy project developers to gain insights from the ground about the current practices, challenges and areas of opportunity regarding the procurement of biomethane from forest biomass and the commercialization, market and potential growth of RNG as a viable low-carbon biofuel in California.

Third, a techno-economic analysis was conducted to explore different policy scenarios that could enhance RNG's competitiveness with respect to other gaseous low-carbon fuels derived from forest biomass. Specifically, we followed a similar approach to Gilani et al (Haris R. Gilani, 2023) and defined different pathways that could help RNG become as profitable, and therefore similarly attractive to project developers, as Hydrogen.

Primary results are discussed in the following section.

3. Main Insights

3.1. Potential future biomass-to-RNG power plants in California

The University of California Woody Biomass Utilization Group (Group, 2023) has one of the largest and most detailed databases available regarding wood utilization facilities in California. This database contains up to date information of 95 operational, closed, or idle biomass power plants. From this pool, a sample was selected based on the facilities' distance to the existing Natural Gas Pipelines. It was found that 18 facilities were 10 miles or less away from an existing pipeline. This sub-sample was further analyzed taking into consideration the available information on the UC WBUG database and the results from the 2019 engineering design study by the Gas Technology Institute (Gas Technology Institute (GTI), 2019). This study estimated the potential biomass utilization, energy production, carbon sequestration and upfront and operational costs if a biomass power plant facility in Stockton, CA was to be retrofit to produce RNG. Based on these results, the volume of woody biomass that could be utilized and the amount of energy in the form of RNG that could be produced if the selected facilities were to be rehabilitated for RNG production were estimated. Figure 1 shows the main findings of this analysis.

The map in Figure 1 shows the geographical distribution of the facilities that this analysis found to have an advantageous location based on their distance to existing natural gas pipeline infrastructure and the density of recoverable forest biomass in their vicinity. In all the graphs of Figure 1 the facilities are color coded based on their current functional statuses, either *Operational*, *Idled*, *Closed* or *Active Development/Proposal/Pilot*. The map also assigns a different size to each facility (individual circles) based on their potential RNG production capacity.

The map shows that the facilities with favorable locations are spread throughout the North of the state and the Central Valley, and that their production capability and functional statuses are evenly distributed. The bar charts show that out of the candidate facilities, 10 are closed or idled. They also show that if these facilities alone were to be rehabilitated for RNG production, they would utilize around 1 million BDT of woody biomass while producing nearly 300,000 GJ of energy in the form of RNG annually. If all proposed facilities were to be upgraded, there would be an annual intake of 2.2 million BDT of woody biomass and a production of around 600,000 GJ equivalent of RNG.

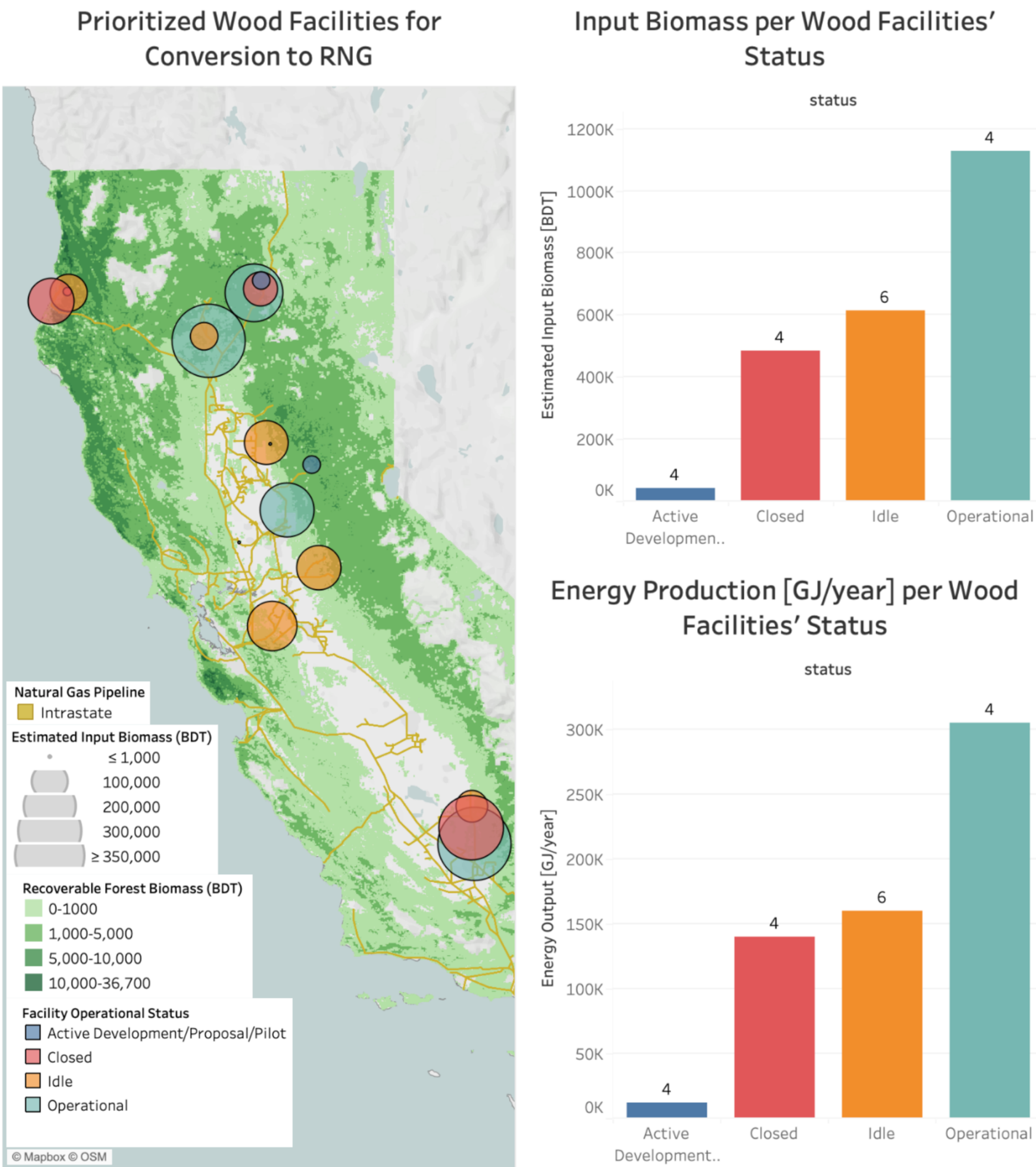

Figure 1. Proposed wood facilities to be prioritized for conversion to RNG production by operational status, and their estimated annual input biomass and annual energy production.

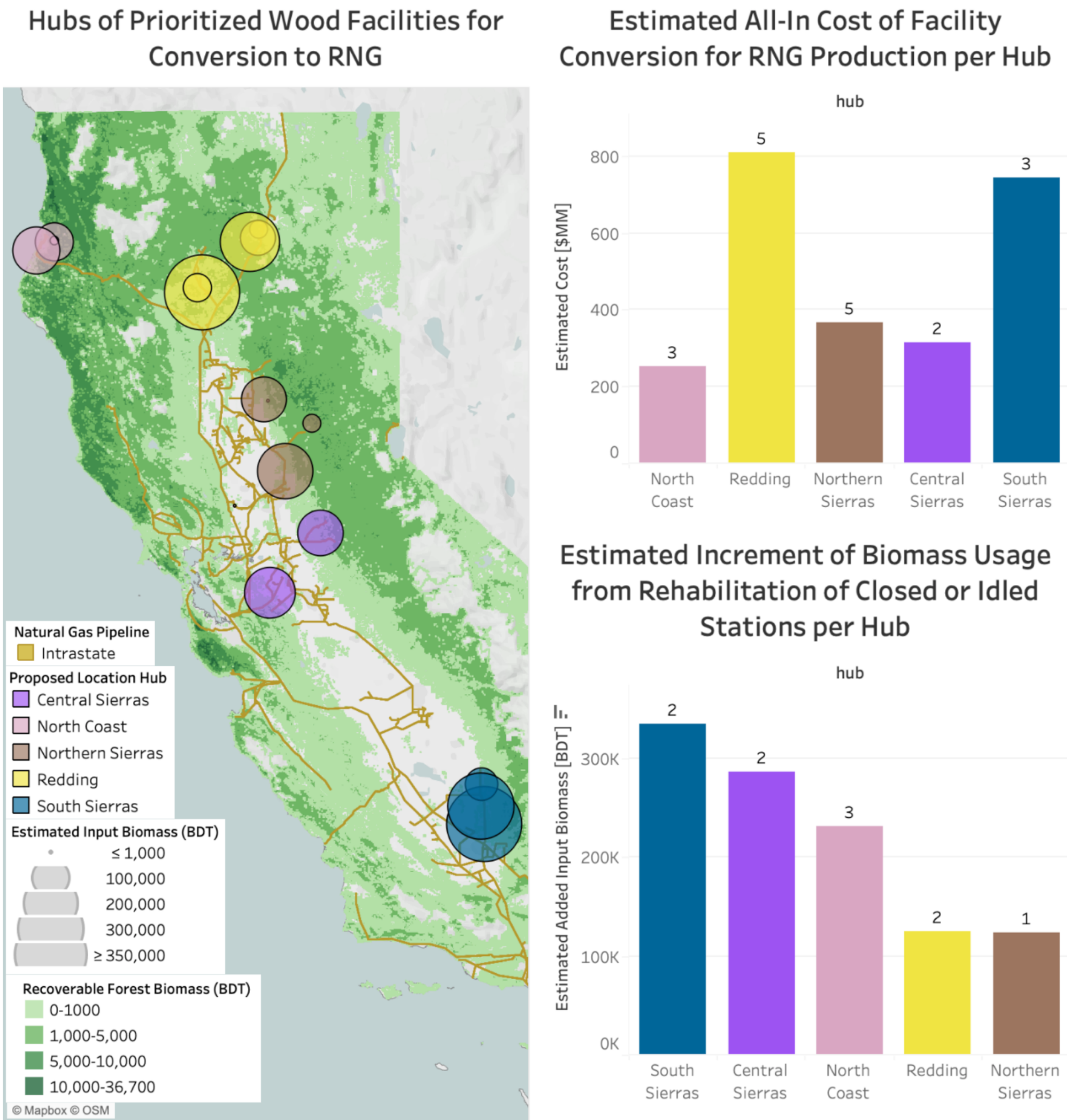

Figure 2. Proposed wood facilities to be prioritized for conversion to RNG production by proposed location hub, the estimated all-in cost of conversion for RNG production, and the estimated increase of woody biomass utilization if closed and idle facilities were rehabilitated.

Following this analysis, the prioritized facilities were grouped into 5 location hubs across the State: *North Coast, Redding, Northern Sierras, Central Sierras* and *South Sierras.* The objective was to focus the subsequent analysis into smaller areas to facilitate possible regional action based on these findings. The location hubs, the estimated all-in cost of facilities conversion for RNG production per hub and the estimated increment of biomass usage from rehabilitation of closed or idled stations per hub is shown in Figure 2.

As it can be observed on the map of Figure 2, each location hub has between two and five individual facilities, each with different sizes and capacities. The top bar chart of Figure 2 shows that the all-in cost of conversion of all facilities in each hub ranges between 250 $MM and 800 $MM. The up-front cost of converting all facilities is around 1.2 billion USD. Costs estimations are directly proportional to the potential RNG production of each hub and its facilities. For instance, upgrading all facilities in *Redding* would cost around 810 $MM, which would be the most expensive of the hubs, but it would lead to a production of RNG equivalent to 200,000 GJ annually, which is equivalent to 70% of all potential energy production. The bottom bar chart shows how much woody biomass would be utilized per hub if only closed and idled facilities are rehabilitated for RNG production. If operational facilities are upgraded for RNG production, they would have a sizable impact in the production of energy from low-carbon fuels, as shown so far. The fact that they are currently running, however, implies that a portion of the input biomass they will require is already being used each year. Therefore, to quantify the net increment of woody biomass utilization that each hub can contribute, only closed and idled facilities are considered. The figure shows the *South Sierras* is the hub with the highest estimated added input biomass, followed by the *Central Sierras* hub and the northern hubs.

These results were then compared to the Proposed Governor's Wildfire and Forest Resilience Task Force Wood Utilization Strategy (WUS), as shown in Figure 3. The data for the top chart in the figure was taken from the September 2023 WUS draft and it shows the target volumes of woody biomass utilization in California from now until 2035. The bottom left chart compares the state's volume target for clean fuels and the potential contribution to that target that closed and idled facilities could have should they be rehabilitated for RNG production. As the figure shows, these 10 facilities alone could comprise over 16% of the biomass utilization target.

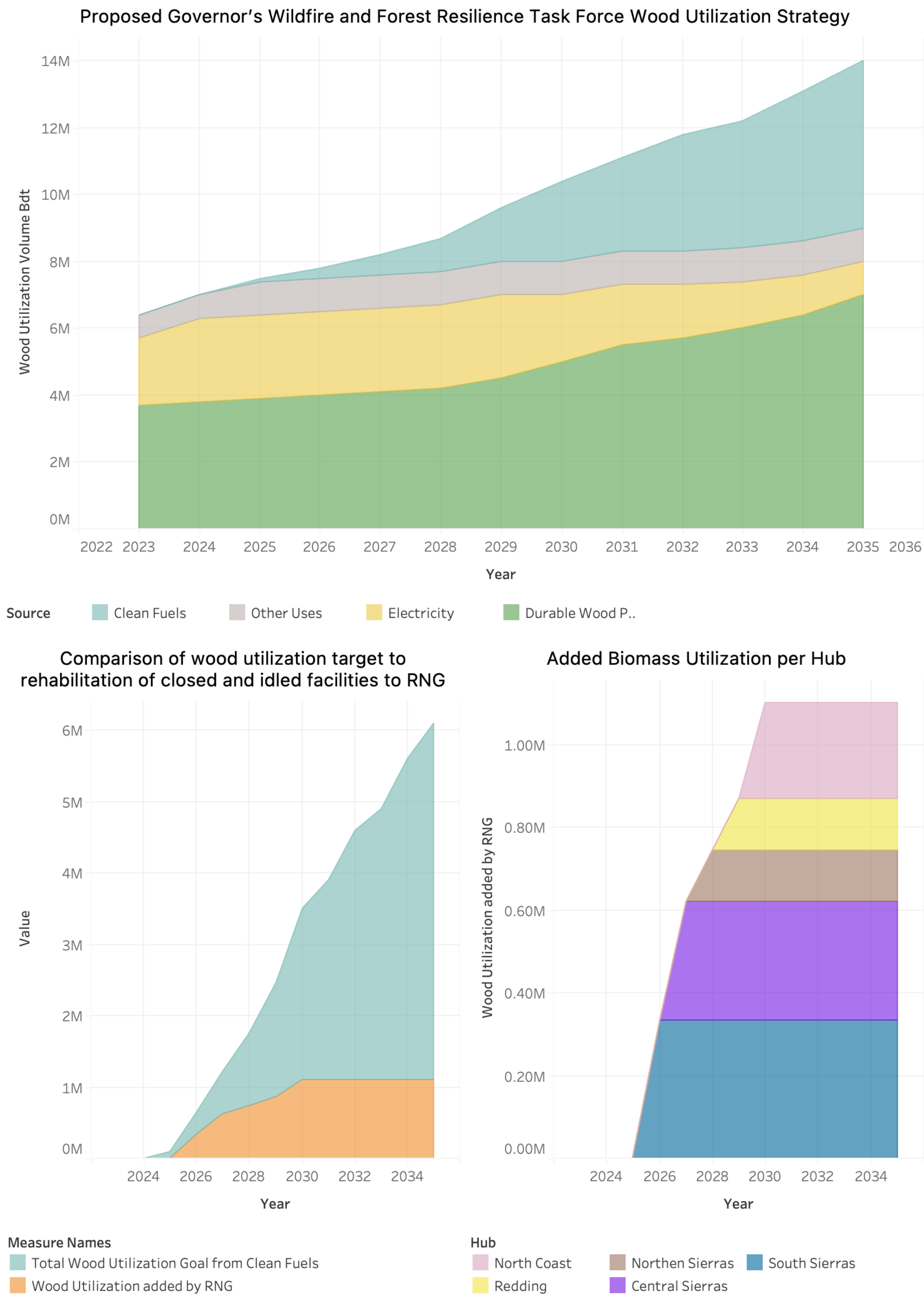

Figure 3. Potential contribution of proposed hubs to the State's Biomass Utilization Targets.

Finally, the bottom right chart in Figure 3 shows a hypothetical scenario in which the volume of woody biomass for clean biofuels ramps ups by over 1 MBDT between 2025 and 2030 through the rehabilitation of the closed and idled facilities of each hub, starting in the *South Sierras* and moving northward up to the *North Coast* hub.

3.2. Learnings from the ground: Conversations with biofuel practitioners

As part of this study, we had conversations via Zoom with the leadership of Yosemite Clean Energy, West Biofuels and Oberon Fuels. We also had brief email correspondence with San Joaquin Renewables and NXTClean Fuels. The objective of these conversations was to gain a deeper understanding of the current realities, challenges and opportunities of RNG production and commercialization. The main ideas shared in these conversations are summarized below.

3.2.1. Policy must create a favorable ecosystem for RNG commercialization.

When PG&E proposed the current RNG pilot project lead by West Biofuels as part of the implementation of Senate Bills 1440 the aim was to address the key technical constraints driving the high cost of the current RNG production process. At the time, however, it was known that one of the main limitations to the commercialization of RNG would be the relatively high production costs of renewable natural gas in California. Since the technology to produce RNG from woody biomass and the supply chain needed to make it available to end users is not as mature the United States as other sources of clean energy, its financing represents a risky venture for private parties. SB 1440's intent to procure RNG through investor owned utilities reduces risk as these are typically credit-worthy counterparties. Moving forward, there is a present need for further synergy between subsequent SB 1440 implementation and the Department of Conservation's forests and biofuel programs, as well as other relevant state and federal low-carbon fuels policies, including the Renewable Fuel Standard (EPA, 2023) and the Low Carbon Fuel Standard (CARB, 2023).

3.2.2. Hydrogen is a key competitor to RNG.

Hydrogen and RNG share several similarities in their production processes, which means there is both technical capability and disposition to produce RNG from woody biomass. Nevertheless, the current Hydrogen selling price is more than twice of RNG per energy unit, making it much more attractive for developers to produce Hydrogen. This is a key practical example illustrating the consequences of the lack of supportive policies for the commercialization of RNG. Based on this feedback, we implemented a techno-economic analysis and a discounted cashflow model to explore different potential policy scenarios that could enhance the market competitiveness of RNG.

3.2.3. RNG is not a likely destination for California's climate policy but is a part of its decarbonization journey.

During the interviews with the field experts and practitioners, the comparison of RNG to other fuels such as Hydrogen brought the conversations back to the role that RNG can play into the overall state's clean energy transition. An important conclusion reached in these dialogs was that RNG procurement is not an end goal for California's energy system and climate policy; rather it is a relevant step in the journey towards a sustainable low-carbon future. This implies that at present RNG might not garner as much support as other fuel alternatives because there is a preference for energy sources that are not combusted or produce zero emissions for all pollutants. This also makes it possible that California's commitment to RNG may wane in the long-term. Nevertheless, there are important near-term advantages that RNG presents that make it a viable pathway to reduce emissions for the next 10 to 20 years. Such advantages include possibility of utilizing existing statewide infrastructure for its procurement and distribution, the feasibility of CO2 capture and sequestration during RNG production, and RNG's well-known efficiency and versatility as a fuel. RNG may not be a permanent solution in CA, but it likely has a role to play in its energy transition.

3.2.4. Microgrids are an exciting potential end-use for RNG.

During the conversations with the experts there was significant reassurance that producers will have interest on generating RNG alongside with Hydrogen should the market exist for it. This is mainly because the cost, the processes, and therefore the technical requirements for their production for their procurement are similar. This willingness suggests it would be beneficial for the state to support the development of RNG's end uses. A remarkable example of the potential that RNG offers to repurpose existing infrastructure for a low-carbon transition are microgrids. Microsoft, in collaboration with Enchanted Rock, announced in June 2022 the development of an agricultural waste derived RNG microgrid in San Jose, CA, with the objective of moving away from diesel fuel permanently. This project advances Microsoft's internal goal of eliminating dependance on petroleum-based diesel and increases the resilience of Microsoft data center without adding further stress to the local grid. A key microgrid advantage is the enabling of on-site production from multiple energy sources, which allows the data centers to operate independently from the grid. This becomes key during outages or in times of grid malfunction.

The company has previously implemented hydrogen fuel cells and eco-diesel in other data centers, so this is not Microsoft's first attempt at green energy decentralization. Enchanted Rock's leadership has described this project as an opportunity to demonstrate that it is possible to standardize large-scale, reliable and cost-effective back-up energy generation with net-zero carbon. They foresee that the project "will outperform current California Air Resources Board's stringent emissions requirements for distributed generation, with hourly local emissions 80 to 90 percent lower than Tier 4 diesel standards, while delivering higher reliability" (Miller, 2015). This is planned to be achieved by producing RNG on site and injecting it into the natural gas pipeline directly upstream of the center. The project's leadership is confident on the reliability of their technological design, and the established supply chain and providers required for their success. The project is supposed to start operations in 2024 (Miller, 2015). This is just one example of growing use for RNG in microgrids.

3.3. Scenarios of cost-competitive forest-biomass-to-fuel pathways for RNG

Based on the insights from the interviews with project developers and field experts, it seemed advantageous to explore different ways in which current state and federal policy could be modified to enhance RNG's competitiveness with hydrogen. Therefore, a discounted cash flow model to assess profitability in terms of internal rate of return (IRR) and sensitive analysis on feedstock and capital cost prices were implemented with the objective of identifying scenarios in which RNG could become as economically viable as Hydrogen. The followed methodology for this analysis is based on Gilani's techno-economic and policy analysis between hydrogen and gasoline (Gilani et al, 2023), using RNG cost and performance metrics estimated by the Gas Technology Institute.

Hydrogen and hydrogen w/ CCS facilities are likely profitable in California. Hydrogen derives revenues from fuel sales, LCFS credits, RFS credits, hydrogen tax credits, and/or carbon sequestration tax credits. As a result, a \$100 million facility producing half a million GJ of hydrogen per year with CCS has a net present value (NPV) of 475 and an internal rate of return (IRR) of 48% over a 20-yr lifetime, and an NPV of 280 and an IRR of 31% without CCS. RNG faces a different costs and revenues. A \$340 million facility producing 2 million GJ of RNG per year has a NPV of -\$630 million (loss) and no return over a 20-yr lifetime in a baseline scenario.

The following are potential scenarios in which RNG's profitability is equaled to that of Hydrogen. This method is described further in Gilani et al. 2023.

3.3.1. Modifications to RNG's market value

First, it was found that without any other change in relevant policies the selling cost of RNG would have to be increased from approximately \$4.00/GJ, as it currently stands, to \$51.21/GJ with carbon capture sequestration (CCS) to achieve an IRR of 48%, and \$46.26/GJ without CCS to achieve an IRR of 31%. This represents an increase between 115% and 130%. This also means that if no other policy is modified to support economic viability, the market price of RNG would have to increase by more than a factor of 10 to be economically competitive with Hydrogen.

3.3.2. Adding RNG to the Low Carbon Fuel Standard and the Renewable Fuel Standard

We then explored the possibility of integrating RNG into the Low Carbon Fuel Standard (LCFS) and the Renewable Fuel Standard, as is the case for hydrogen. This is because of the critical impact LCFS and RFS currently have in the profitability of biofuels in California (Gilani et al. 2023). To match hydrogen's profitability, it was calculated that RNG would need to be granted LCFS credits worth $332.14 per ton abated if it remained at the same market price of $4.00/GJ. Similarly, it was calculated that at current market price RNG would have to gain $13.84 per RFS RIN at its current market price of $4.00/GJ. It is worth nothing that these values are dependent on the RNG production facilities attaining a theoretical carbon intensity of -60 gCO2e/MJ (Gas Technology Institute (GTI), 2019). For reference, a sensibility analysis of the potential value of LCFS credits and RFS RINs on carbon intensity was done. The results from the analysis are shown in Figure 4.

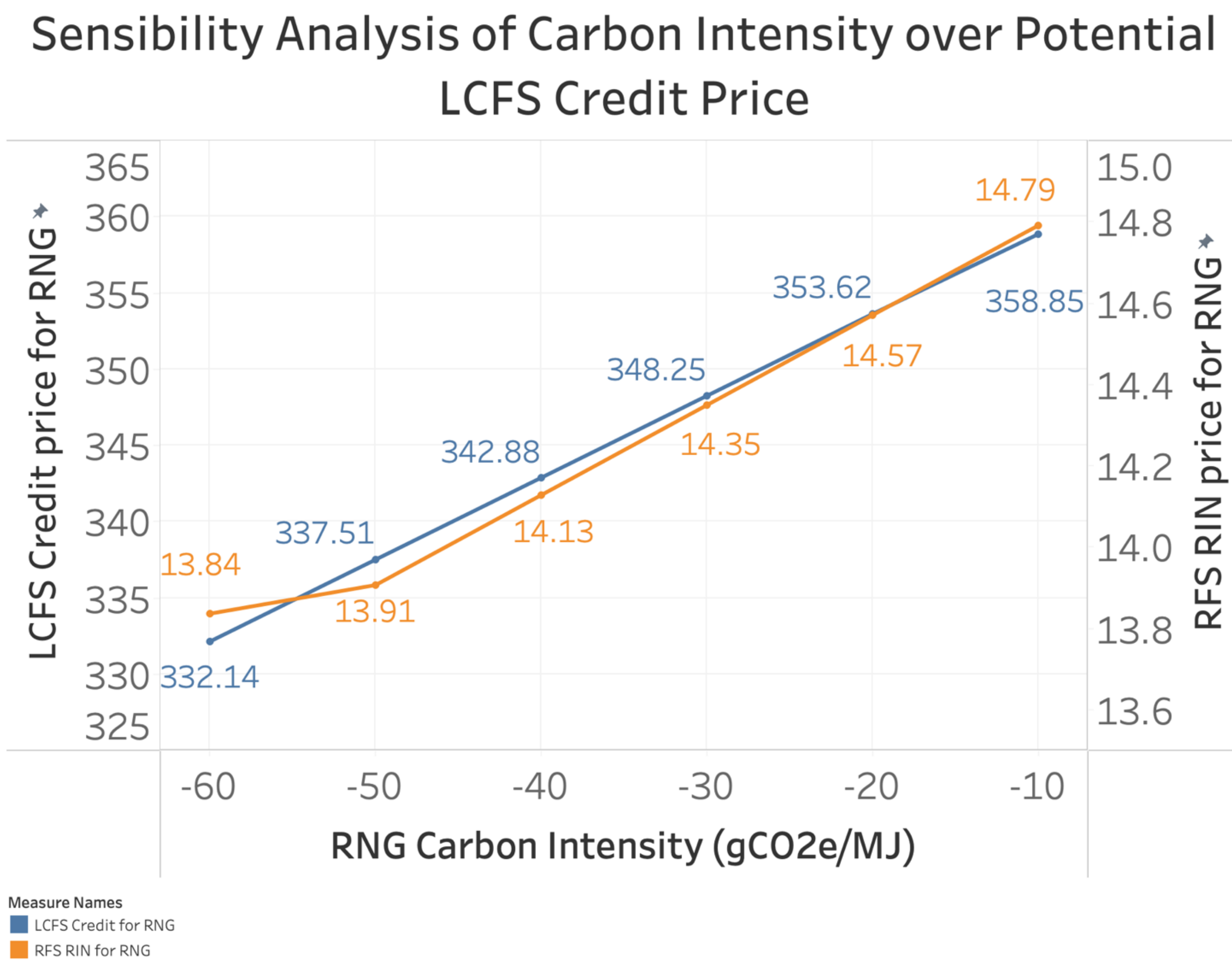

Figure 4. Sensibility analysis of carbon intensity over potential Low Carbon Fuel Standard credit and Renewable Fuels Standard RIN value for RNG profitability.

3.3.3. Capital cost subsidy

To improve the profitability of RNG projects, the state could give grants for systems in California to cover part of their capital costs. Our analysis showed that without any other policy or pricing change, the state would have to subsize 125% of the capital cost of RNG projects with CCS at current RNG fuel cost ($4.00/GJ), or 155% of the capital cost of RNG projects without CCS at current RNG fuel cost ($4.00/GJ).

The identified scenarios for RNG profitability are summarized below in Table 1.

Scenario	New RNG Market Value ($/GJ)	Adding RNG to LCFS ($/ton abated)	Adding RNG to RFS ($/RIN)	Capital Cost Subsidy (%)
With CCS (48% IRR)	$51.21	$332.14	$13.84	125%
Without CCS (31% IRR)	$46.26	-	-	155%

Table 1. Summary of different scenarios of cost-competitive forest-biomass-to-fuel pathways for RNG.

4. Recommendations for RNG Procurement from Forest Biomass

Based on the learnings described in the previous section, four recommendations for RNG procurement from forest biomass presented and discussed as follows.

4.1 Enable the repurposing of existing infrastructure for a low-carbon future.

One of the main advantages that RNG offers is the possibility of reproposing existing infrastructure to produce low-carbon fuels. As shown in section 3.1 in this report, there are biomass power plants with advantageous locations throughout California, namely, in sites that are 10 miles or less from a natural gas pipeline and with significant recoverable forest density within a 25-mile radius. These plants are good candidates for rehabilitation to produce RNG. There is an opportunity to produce additional energy from RNG equivalent to almost 275,000 GJ annually while increasing the state's utilization of woody biomass by 1.1 million BDT per year. This can be achieved by opening 10 closed and idled biomass power plants and refurbishing them to produce RNG. Prioritizing the transformation of this facilities could serve as a proof of concept to the ramp up of biofuel production and woody biomass utilization that can be achieved from infrastructural reproposing for RNG production. The proposed sites, which are currently idle, are listed in Table 2.

Facility Name	County	Hub	Estimated RNG Production (GJ/year)
Blue Lake Power	Humboldt	North Coast	23,785.83
DG Fairhaven	Humboldt	North Coast	37,230.00
Blue Lake Rancheria	Humboldt	North Coast	1,654.67
Covanta Burney Mtn. Power	Shasta	Redding	34,127.50
Shasta Renewable	Shasta	Redding	12,410.00
Covanta Pacific Oroville Power	Butte	Northern Sierras	34,127.50
Buena Vista Biomass Power	Amador	Central Sierras	33,093.33
Tracy Biomass Power	San Joaquin	Central Sierras	40,125.67
Sierra Biomass Power Corp.	Tulare	South Sierras	16,546.67
Rio Bravo Jasmin	Kern	South Sierras	40,125.67
Total Estimated Energy Production (GJ/year)			**273,226.84**

Table 2. Proposed closed and idled biomass power plants facilities for rehabilitation for production of RNG from forest biomass.

4.2. Embrace RNG as a time-limited climate solution.

One of the challenges with the implementation of RNG as a low-carbon solution is that it is not always the lowest-emission resource available for decarbonizing the energy market. As pointed by energy analysts such as Emily Grubert, RNG is likely to provide fewer net emissions benefits overtime than its competitors. Furthermore, if RNG production is implemented in the scale needed to meet a significant statewide demand, potential methane leakage from biogas production could make RNG climate intensive (Grubert, 2020). Therefore, it is important to recognize and embrace that RNG is a time-limited solution for the state. This, however, does not mean that RNG has no part of California's transition to a low-carbon future. Forest biomass to RNG pathways offer a time window of 10 to 20 years in which existing infrastructure can serve to reduce GHG emissions and to implement relevant action for forestry management and wildfire mitigation.

4.3. Enhance the economic viability of RNG projects by procuring RNG for use as a transportation fuel.

The economic analysis done for this report showed that if no policy or market changes are enacted support RNG projects financial viability, the state may have to give significant subsides to the projects capital costs of the magnitude of 125% to 155% of the total capital cost. Therefore, it would be advantageous for the CPUC to expand the current mandate to consider the utilization of RNG as a transportation fuel, where RNG may face better economics. If future rule makings consider RNG as an alternative transportation fuel, then these projects could take advantage of credits under the Low Carbon Fuel Standard and the Renewable Fuel Standard, which play a crucial part in the financial success of other forest biomass to biofuels pathways.

4.4. Ensure the demand for other forest-derived biofuels as alternatives to RNG.

In addition to examining the potential benefit of subsidies for RNG projects and the modification of the CPUC mandate to utilize RNG as a biofuel for transportation, it would be beneficial for the state to ensure the demand of forest biofuels by supporting alternative end uses throughout California. Other gaseous or liquid fuels, such as hydrogen and drop-in liquid fuels, may prove more important markets in the short-term.

Finally, there are still untapped growth areas for decarbonizing energy usage in California, especially in underserved rural communities of the state. During the interviews it was point out that propane is widely used in these areas, and that lower-emissions biofuels could present an efficient and cost-effective way to accelerate the decarbonization process. Such areas of opportunity are likely to be found as California decarbonizes its economy.

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