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*Comment Received From: Southern California Gas Company  
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**SoCalGas Comments on the CEC 2021 Draft IEPR**

*Additional submitted attachment is included below.*



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December 21, 2021

Commissioner J. Andrew McAllister  
Vice Chair Siva Gunda  
California Energy Commission  
Docket Unit, MS-4  
Docket No. 21-IEPR-01  
1516 Ninth Street  
Sacramento, CA 95814-5512

**Subject: Comments on the 2021 Draft Integrated Energy Policy Report (IPER)**

Dear Commissioner McAllister and Vice Chair Gunda:

Southern California Gas Company (SoCalGas) appreciates the opportunity to provide public comments on the California Energy Commission (CEC) 2021 Draft IEPR released on December 7, 2021. We recognize and appreciate the sheer volume of work the IEPR staff, subject matter experts and Commissioners (both the CEC and CPUC) have put into planning, developing, and hosting the thirty-nine IEPR workshops in 2021. We also welcome the opportunity to be included in the IEPR process and conversations with the CEC. We have submitted 20 comment letters in response to IEPR workshops in 2021<sup>1</sup> and acknowledge and thank the CEC efforts to incorporate our feedback in the following areas:

- The CEC addressed the concerns we presented in our comment letters response to the CEC’s Midterm Reliability workshops and conversations with CEC staff.<sup>2</sup> The CEC acknowledged that natural gas is not less reliable than renewables in the phrase “these [modeling analysis] results do not indicate that a portfolio consisting of zero-emitting or thermal resources are inherently less reliable.”<sup>3</sup>
- The CEC acknowledged and incorporated the suggestion we presented in our comment letter in response to the IEPR Workshop on the Role of Energy Efficiency in Building

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<sup>1</sup> We have submitted twenty-five additional comment letters in response to other CEC proceedings throughout 2021.

<sup>2</sup> See “SoCalGas Comments on the Midterm Reliability Analysis,” September 7, 2021, available at: <https://efiling.energy.ca.gov/GetDocument.aspx?tn=239604&DocumentContentId=73037>.

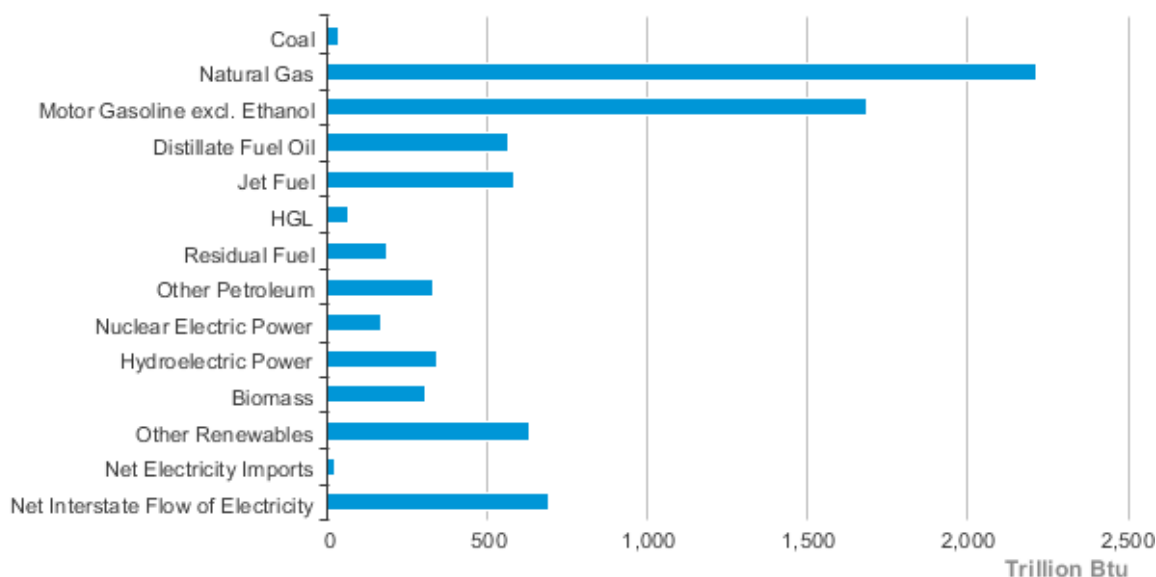
<sup>3</sup> See 2021 Draft Integrated Energy Policy Report (IEPR), CEC, Volume II, pg. 61, available at: <https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2021-integrated-energy-policy-report>.

Decarbonization.<sup>4</sup> We recommended the State provide a supporting role for municipalities interested in issuing green bonds through technical assistance and financial means.

- The CEC recognized the role of clean molecules in the decarbonization of hard to abate sectors like industrial.
- The CEC recognized various literature sources for indoor air quality implications and the need for additional research.
- The CEC has included consideration of green hydrogen as a zero-emission fuel for use in the transportation sector.

Unquestionably, we need to change the energy system to achieve the State’s climate goals to achieve net-zero emissions by 2045. As a core element of this transition, gaseous molecules will continue to play an indispensable role in supporting electrification and Senate Bill (SB) 100 compliance, in addition to users across all customer classes for whom electrification is not feasible. Currently, natural gas serves every sector of California’s economy. On an energy basis, it is the most used energy source in the State. Figure A shows total energy consumption in California by fuel source on a British Thermal Unit (BTU) basis.<sup>5</sup> Natural gas supplies 28 percent of the energy consumed in California.

**Figure A: California Energy Consumption by Fuel Source**



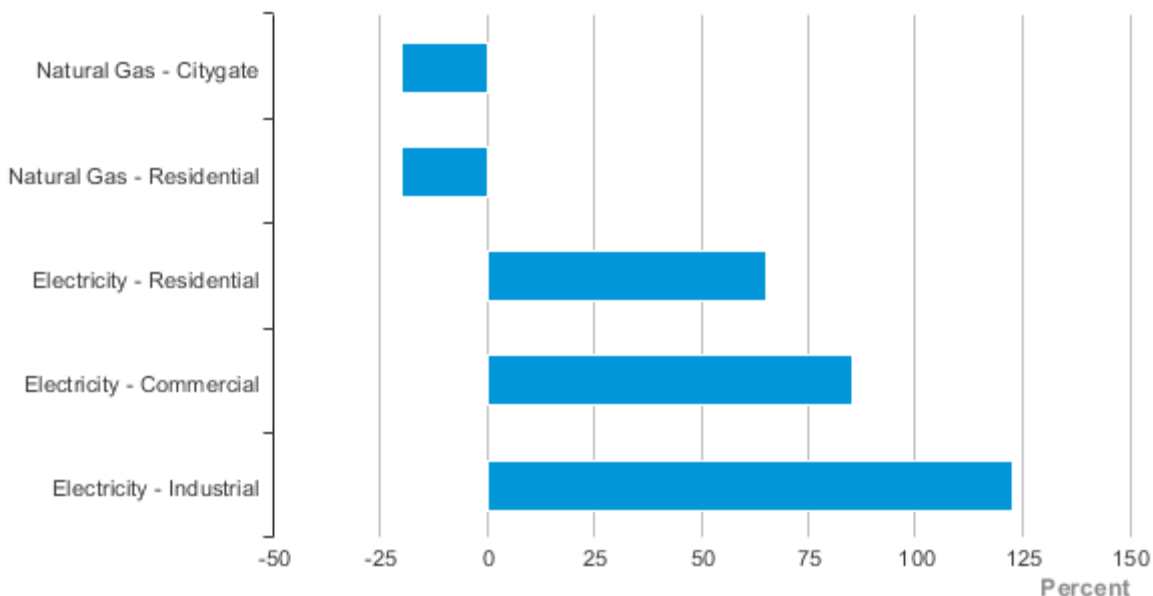
 Source: Energy Information Administration, State Energy Data System

<sup>4</sup> See “SoCalGas Comments on the CEC IEPR Workshop on the Role of Energy Efficiency in Building Decarbonization,” September 7, 2021, available at: <https://efiling.energy.ca.gov/getdocument.aspx?tn=239612>.

<sup>5</sup> See “State Energy Data System,” Energy Information Administration, available at: <https://www.eia.gov/state/?sid=CA#tabs-1>.

It does so cheaper as compared to the rest of the United States, while California’s electricity tends to be more expensive than the rest of the United States. Figure B compares California’s prices of natural gas and electricity to the rest of the United States; negative numbers indicate cheaper than the US average, and positive numbers indicate more expensive.<sup>6</sup>

**Figure B: California Price Differences from the U.S. Average**



Source: Energy Information Administration, Petroleum Marketing Monthly; Natural Gas Monthly; Electric Power Monthly

While the Draft IEPR discussion is thoughtful, detailed, and informative, there are numerous areas where the framing and presentation of relevant issues and alternatives as part of California’s energy transition could be bolstered by additional discussion, facts, and context around energy system reliability, building decarbonization strategies, the energy demand forecast, and clean transportation benefits. Our comments address content in the Draft IEPR that could, if actuated, increase the risk of energy shortage, economic dislocation, and inequitable impacts to affordability and public health and safety.

Additionally, the themes of our comments focus on the CEC’s statutory requirement to complete assessments and forecasts in the IEPR and to develop and evaluate energy policies and programs that conserve resources, protect the environment, ensure energy reliability, enhance the State’s economy, and protect public health and safety.<sup>7</sup> To provide constructive feedback that aligns with the CEC’s statutory requirements in the IEPR, we summarized our comments in the following Appendices:

**Appendix A: Protecting Public Health & Safety and the Environment**

<sup>6</sup> See “Petroleum Market Monthly; Natural Gas Monthly; Electric Power Monthly,” Energy Information Administration, available at <https://www.eia.gov/state/?sid=CA#tabs-5>.

<sup>7</sup> See 2021 Draft IEPR.

1. The proliferation of diesel back-up generators (BUGs) to assure electric reliability is likely to offset some of the benefits of transportation and building decarbonization strategies.
2. This trendline of increased reliance on diesel BUGs to assure reliable electricity is likely to continue to exacerbate adverse air quality and public health effects.
3. Heavy-duty trucks fueled with renewable natural gas (RNG) support decarbonization, public health, and air quality goals by displacing greenhouse gases (GHGs), diesel, and nitrogen oxide (NOx) emissions.

#### **Appendix B: Ensuring Energy Reliability**

4. Blackouts from heatwaves and yearly outages during Public Safety Power Shutoff (PSPS) events are downplayed in the draft to the detriment of ensuring a reliable electric grid.
5. Energy trends in California and across the West warrant conservative assumptions regarding the availability of imports and hydroelectric power to create a clean, reliable, and resilient interdependent California energy system.
6. California's electricity grid increasingly relies on a diminishing gas-fired generation capacity to ensure energy system reliability.
7. Data points indicate the need for long duration storage.
8. High temperatures lessen the operational efficiencies of all electricity generation and transmission assets.
9. The evolving electricity system's increasing reliance on transmission creates challenges.
10. The Draft IEPR should acknowledge that delays in projected battery storage deployment could continue.

#### **Appendix C: Conserving Resources**

11. Load-shifting technologies should be deployed for gas appliances to conserve energy and serve as reliable back-up power to complement Grid-interactive Efficient Buildings (GEBs).
12. Targeting incentives towards non-energy barriers can increase the efficacy of energy conservation and decarbonization programs in disadvantaged communities.

#### **Appendix D: Enhancing the State's Economy**

13. State support for industrial hubs can help scale zero-carbon hydrogen and can provide a decarbonization pathway for high heat and energy-intensive industries.
14. Incentives should be used to advance pilot projects that help bring clean fuels to scale.

#### **Appendix E: Modeling Assumptions, Data Errata & Redline Edits**

15. Funding fuel substitution over gas energy efficiency conflicts with SB 350 and PUC 454.55 and 454.56.

16. TDV metrics should continue to be developed in the Energy Code, while emphasizing that the assumptions embedded into the analysis should reflect the most current data sets available for the cost of electric and gas supply.
17. The classification of factors that constitute the benefit-cost assessment should be presented with greater transparency.
18. Emission reductions are projected to result from electrification, not from decommissioning of natural gas delivery infrastructure.
19. Underlying assumptions used to develop Additional Achievable Fuel Substitution (AAFS) and Long-Term Demand Scenarios should be presented with greater transparency.
20. Lowering the cost-effectiveness threshold for portfolio programs suggests that energy efficiency programs are less effective than expected.
21. Fuel substitution may not align with 2018 Energy Action Plan loading order.
22. Utilizing historical gas consumption data for future IEPRs may not be the most effective approach to advancing the public interest.
23. Clarification is needed regarding the 2022 Reliability Scenarios and Figures.
24. The State's Decarbonization Strategy tends to be misconstrued and conflated with electrification.
25. Imports data and characterization revisions are needed.

In sum, we respectfully suggest that the public interest is advanced by issuance of an IEPR providing complete, transparent, and fulsome information and analysis. In particular, this extends to the role of, and ongoing need for gaseous fuels, and the role that the gas grid plays as a facilitator of decarbonization. As we have previously noted, there would not be any material emissions reductions in the electric grid without the statutorily expressed “essential” services provided by the gas grid. The Legislature’s codification of “essential” services will continue into the foreseeable future, as more fully described in SoCalGas’s recently released Clean Fuels white paper.<sup>8</sup> As so expressed, use of traditional gas by customers is projected to trend downward as we collectively advance California’s decarbonization policies and imperative. At the same time, however, the need for and value of services provided by the gas grid will tend to increase, particularly considering resiliency needs and the decarbonization options for energy customers for whom electrification is not a feasible or realistic option (which applies across all customer segments), and for which gaseous fuels will and must likewise be decarbonized.

To achieve decarbonization and climate goals, we collectively must transform the energy system. While that transformation is largely borne by energy market participants, it also requires significant changes to policy and customer behavior. A lynchpin to the willingness of individuals and the public to change behavior is the availability of adequate and affordable supplies of energy. We respectfully suggest that overlooking or understating supply risks as they pertain to policies, tools, and measures in the Draft IEPR conversely creates the risk of undermining public support for the necessary energy transition due to the prospects for energy shortages and undue or

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<sup>8</sup> See “SoCalGas Clean Fuels,” last modified November 9, 2021, available at <https://www.socalgas.com/sustainability/clean-fuels>.

inequitable cost impacts. California already has experienced some of these adverse outcomes firsthand, most recently in August 2020 as well as on an ongoing basis during PSPS and other outage events. Our comments are framed around suggestions that enhance transparency and the basis for energy policies to advance the energy transition. We look forward to collaborating with the Commission, staff, and all interested stakeholders to continue to develop the means for achieving these existential energy system outcomes.

Respectfully,

*/s/ Kevin Barker*

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## Appendix A: Protecting Public Health & Safety and the Environment

### 1. The proliferation of diesel back-up generators (BUGs) to assure electric reliability is likely to offset some of the benefits of transportation and building decarbonization strategies.

On page 10 of Volume II, it is stated that: “Moving toward 100 percent clean electricity will increase access to clean energy for Californians, reduce air pollution, improve public health, and support the emissions reductions in other sectors, such as transportation and buildings. However, it will continue to require deployment of a large amount of existing and new technologies and a close eye on grid reliability.”<sup>9</sup> We respectfully request that the CEC thoroughly analyze the costs and benefits of policy recommendations in the Draft IEPR that result in a proliferation of diesel-fueled BUGs to ensure reliable electricity.

In response to the need for reliable power, diesel BUGs are growing at a rapid pace in California with enough capacity to power 15 percent of the electric grid.<sup>10</sup> The growing reliance on these higher-emitting generators undermines efforts made by the State regarding climate change mitigation, energy affordability, equity, air quality attainment requirements, and reliability on clean energy resources. Per the California Air Resources Board (CARB), “[the] demand for reliable back-up power has health impacts of its own. Of particular concern are health effects related to emissions from diesel back-up engines. Diesel particulate matter (DPM) has been identified as a toxic air contaminant, composed of carbon particles and numerous organic compounds, including over forty known cancer-causing organic substances. The majority of DPM is small enough to be inhaled deep into the lungs and make them more susceptible to injury.”<sup>11</sup> According to the Mount Sinai Selikoff Center for Occupational Health, long-term exposure to diesel exhaust can cause the worsening of existing lung conditions, such as asthma.<sup>12</sup> The increase in diesel generation statewide is troublesome, as the generators tend to be located near public spaces, such as schools and workplaces.<sup>13</sup> Even more concerning is that many of the diesel generators are located within disadvantaged communities and can potentially burden these residents with high levels of carcinogenic pollutants.<sup>14</sup>

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<sup>9</sup> See 2021 Draft IEPR, Volume II, pg. 10.

<sup>10</sup> See “The Diesel-Fired California Dream,” California Energy Markets, October 8, 2021, No. 1662, available at [https://www.newsdata.com/california\\_energy\\_markets/bottom\\_lines/the-diesel-fired-california-dream/article\\_f65b1070-2876-11ec-b3f1-f3ef2c8a4076.html](https://www.newsdata.com/california_energy_markets/bottom_lines/the-diesel-fired-california-dream/article_f65b1070-2876-11ec-b3f1-f3ef2c8a4076.html).

<sup>11</sup> See “Use of Back-up Engines for Electricity Generation During Public Safety Power Shutoff Events,” California Air Resources Board, October 25, 2019, available at <https://ww2.arb.ca.gov/resources/fact-sheets/carb-regulations-allow-use-back-generators-during-public-safety-power-shutoff#:~:text=During%20these%20Public%20Safety%20Power%20Shutoffs%20%28PSPS%29%2C%20you,to%20use%20your%20back-up%20generators%20during%20a%20PSPS.>

<sup>12</sup> See Mount Sinai Selikoff Centers for Occupational Health, Diesel Exhaust Exposure, revised May 2016, available at <https://www.mountsinai.org/files/MSHealth/Assets/HS/Patient%20Care/Service-Areas/Occupational%20Medicine/Diesel%20Exhaust%20Exposure.pdf>.

<sup>13</sup> See “Diesel Back-Up Generator Population Grows Rapidly in the Bay Area and Southern California,” M. Cubed, available at <https://www.bloomenergy.com/wp-content/uploads/diesel-back-up-generator-population-grows-rapidly.pdf>.

<sup>14</sup> *Ibid.*

The proliferation of diesel BUGs is likely to offset some of the benefits of transportation and building decarbonization strategies. For example, nearly one million people were affected by a PSPS event in October 2019 and utilized 125,000 BUGs for electrical power.<sup>15</sup> CARB estimated that diesel BUGs used during this time emitted 9 tons of diesel soot, which is the equivalent of about 29,000 heavy-duty diesel trucks driving on California’s roadways for one month.<sup>16</sup> South Coast AQMD estimates that in 2019, diesel BUGs emitted approximately 6 tons of NOx during a PSPS event<sup>17</sup>, meaning that such emissions are offsetting NOx emissions reduction measures which should be expected to increase in the future.

**2. This trendline of increased reliance on diesel BUGs to assure reliable electricity is likely to continue to exacerbate adverse air quality and public health effects.**

On page 4 of Volume II, the Draft IEPR states: “... the state can procure and deploy temporary mobile generators to add supply.”<sup>18</sup> Recommending the state to procure temporary generators which likely are diesel or gasoline fueled seems acknowledge a deficiency in the state long term energy planning. The Energy Commission’s power plant certification responsibilities also have seen an increase in diesel BUGs requesting Small Power Plant Exemption permits. Since 2018 the Energy Commission has approved 264 diesel generators representing about 540 MW of capacity at six data centers.<sup>19,20,21,22</sup>

The Draft IEPR refers to the Governor’s Emergency Proclamation, which empowered the Energy Commission with authority to permit additional capacity at CEC-approved existing power plants and new generation capacity of thermal and batteries for projects greater than 10 MW and 20 MW, respectively. At the August 17, 2021, and September 8, 2021, Business Meetings, the Energy Commission delegated their authority to approve these capacity expansions, new power plants,

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<sup>15</sup> See “Emission Impact: Additional Generator Usage Associated with Power Outage,” January 30, 2020, available at [https://ww2.arb.ca.gov/sites/default/files/2020-01/Emissions\\_Inventory\\_Generator\\_Demand%20Usage\\_During\\_Power\\_Outage\\_01\\_30\\_20.pdf](https://ww2.arb.ca.gov/sites/default/files/2020-01/Emissions_Inventory_Generator_Demand%20Usage_During_Power_Outage_01_30_20.pdf).

<sup>16</sup> *Ibid.*

<sup>17</sup> See “Legislative Update Presentation by Philip Crabbe to the Environmental Justice Community Partnership Advisory Council,” South Coast AQMD, September 2, 2020, available at <http://www.aqmd.gov/home/news-events/webcast/live-webcast?ms=0U9KfvvcV3w>.

<sup>18</sup> See 2021 Draft IEPR, Volume II, pg. 4.

<sup>19</sup> See “Alphabetical Power Plant Listing,” CEC, available at: <https://www.energy.ca.gov/programs-and-topics/topics/power-plants/alphabetical-power-plant-listing>.

<sup>20</sup> *Ibid.*

<sup>21</sup> Information regarding total capacity of the diesel generators within the listed generating facility is interpreted and calculated such that the listed capacity on the CEC Blue Highlight Table, is the total capacity of the diesel generators contained within the facility. Additionally, the total number of diesel generators were obtained solely from the data listed within the Alphabetical Listing Resource and are subject to change.

<sup>22</sup> See “SoCalGas Comments Track 2 Microgrid Proceeding,” California Public Utilities Commission.

and battery systems to the Executive Director.<sup>23, 24, 25, 26</sup> This delegation of authority lacks a public process and has created less transparency into understanding how many systems applied, were approved, and what those environmental or public health impacts might be. We respectfully request that in matters in which the Commission's activities materially impact public health, including adverse effects, that transparency serves the public interest and fundamental constitutional tenets of governance. We respectfully request the Energy Commission fully report in the IEPR the details of all projects that applied and were granted permits through this process.

### **3. Heavy-duty trucks fueled with renewable natural gas (RNG) support decarbonization, public health, and air quality goals by displacing greenhouse gases (GHGs), diesel, and nitrogen oxide (NOx) emissions.**

Both Volume IV and the Appendix make numerous references to zero-emission fuels and vehicles. Near-zero emission (NZE) fuels and vehicles in the heavy-duty (HD) trucking sector offer tremendous opportunity to reduce emissions, to do so immediately rather than wait for technological developments, and to do so at carbon intensity improvements that surpass what would be achieved otherwise. As the Energy Commission works with the Governor's Office on reauthorization of the Clean Transportation Program, we recommend the program continue to include some funds for carbon neutral and carbon negative fuel production as they are the most cost-effective ways to immediately reduce greenhouse gas emissions from the transportation sector.

To complement existing incentive programs managed by CARB and the air quality management districts, we suggest for the CEC to fund a fuel card program to help offset the upfront costs of owning and operating a HD truck fueled with NZE fuels, such as RNG and hydrogen. This could encourage HD trucks to utilize RNG and/or hydrogen fuel and, thereby, greatly reduce GHG emissions from the heavy-duty sector. The SCAQMD and the San Joaquin Valley Air Pollution Control District (SJVAPCD) have expressed support for a fuel card program due to its potential to help further public health and clean air goals, especially in disadvantaged communities located near major trucking corridors. Such a program could be similar to the Natural Gas Vehicle Incentive Program, funded out of the Clean Transportation Program which provided incentives up to \$25,000 per vehicle purchased,<sup>27</sup> and lay the foundation for offsetting the cost of owning a fuel cell heavy-duty truck that is commercialized and feasible. Fuel cards could provide customers who purchase a new HD Class 8 NZE truck or hydrogen fuel cell electric truck that is pre-loaded with a balance at an amount designed to improve economics and encourage adoption. For example, for

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<sup>23</sup> See Agenda of the August 17, 2021, CEC Business Meeting, available at [https://www.energy.ca.gov/sites/default/files/2021-08/2021-08-17\\_Agenda.pdf](https://www.energy.ca.gov/sites/default/files/2021-08/2021-08-17_Agenda.pdf).

<sup>24</sup> See Backup Material of the August 17, 2021, CEC Business Meeting, available at <https://www.energy.ca.gov/files/august-17-2021-business-meeting-packets>.

<sup>25</sup> See Agenda for the September 8, 2021, CEC Business Meeting, available at: [https://www.energy.ca.gov/sites/default/files/2021-08/2021-09-08\\_Business\\_Meeting\\_Agenda\\_ADA.pdf](https://www.energy.ca.gov/sites/default/files/2021-08/2021-09-08_Business_Meeting_Agenda_ADA.pdf).

<sup>26</sup> See Backup Material for the September 8, 2021, CEC Business Meeting, available at <https://www.energy.ca.gov/files/september-8-2021-business-meeting-packets>.

<sup>27</sup> "Natural Gas Vehicle (NGV) Incentives," last modified July 23, 2020, available at <https://afdc.energy.gov/laws/11647>.

a HD Class 8 NZE truck with a \$60,000 incremental cost (compared to diesel) that travels 72,000 miles per year, a fuel card of \$10,000 could improve the payback from about 4.4 years to 2.5 years.<sup>28,29</sup>

In a recent letter to environmental justice and advocacy groups, SCAQMD Executive Director Wayne Nastri noted that addressing climate change and reducing air pollution reduction "can and must go hand-in-hand" and pointed out that currently-available RNG-powered HD trucks can "provide substantial GHG emission reductions," and are "at least 90 percent cleaner than new diesel trucks on NOx [the air pollutant nitrogen oxide] and 100 percent cleaner on cancer-causing diesel particulate matter."<sup>30</sup> Forty-five percent of the methane emissions in California are fugitive emissions from landfills and dairy manure that can be captured and used productively.<sup>31</sup> RNG can be produced from landfills, animal manure, and solid waste – thereby avoiding the release of methane that would otherwise escape into the atmosphere. RNG is currently helping California reduce short-lived climate pollutants (SLCPs) and criteria air pollutant emissions, particularly as a transportation fuel in NZE HD trucks.

In addition, a recent peer-reviewed study by the University of California, Riverside published in the journal "Transportation Research Part D" reinforces that HD trucks fueled with RNG should be rapidly deployed in the 2020-2040 timeframe to achieve GHG and NOx emission reduction targets, and "accelerating [the diesel trucks] fleet turnover is a more important NOx control strategy than dividing up vehicle replacements...between near-zero-emissions and zero-emissions vehicles."<sup>32</sup> Already today, RNG, and natural gas, HD trucks meet or exceed CARB's low NOx standard of 0.02 grams of NOx per brake horsepower-hour (low NOx trucks), whereas the Clean Truck Rule exempts diesel trucks from that requirement until 2027 – letting higher-emitting vehicles off the hook and postponing emission reductions from what could be achieved now.<sup>33</sup>

As of April 2019, SoCalGas has supported the RNG market by dispensing 100 percent RNG at all utility-owned refueling stations. CARB LCFS reporting showed that by the beginning of 2020, 98 percent of all the natural gas being used in motor vehicles was RNG.<sup>34</sup> RNG procured and dispensed at utility-owned refueling stations had a carbon intensity (CI) of -5.845 gCO<sub>2</sub>e/MJ.<sup>35</sup>

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<sup>28</sup> "Advanced Clean Fleets: Cost Workshop Cost Data and Methodology Discussion Draft," CARB, December 4, 2020, p. 3.

<sup>29</sup> "Average Annual Vehicle Miles Traveled by Major Vehicle Category," last modified February 2020, available at <https://afdc.energy.gov/data/10309>.

<sup>30</sup> Nastri, Wayne. "Letter to Partners in Environmental Justice and Environmental Health," August 3, 2021.

<sup>31</sup> CARB 2022 Scoping Plan Update – Short-Lived Climate Pollutants Workshop Presentation on September 8, 2021, available at [https://ww2.arb.ca.gov/sites/default/files/2021-09/carb\\_presentation\\_sp\\_slcp\\_september2021\\_0.pdf](https://ww2.arb.ca.gov/sites/default/files/2021-09/carb_presentation_sp_slcp_september2021_0.pdf).

<sup>32</sup> Arun S.K. Raju, Barry R. Wallerstein, Kent C. Johnson, "Achieving NOx and Greenhouse gas emissions goals in California's Heavy-Duty transportation sector," *Transportation Research Part D: Transport and Environment*, Volume 97, 2021, August 2021, available at <https://www.sciencedirect.com/science/article/pii/S1361920921001826>.

<sup>33</sup> Miller, Eric, "CARB Formally Adopts Low-NOx Omnibus Rule," *Transport Topics*, August 28, 2020, available at <https://www.ttnews.com/articles/carb-formally-adopts-low-nox-omnibus-rule>. //

<sup>34</sup> "CARB LCFS Data Dashboard, Figure 2," last modified April 2, 2021, available at <https://www.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm>.

<sup>35</sup> "LCFS Pathway Certified Carbon Intensities," CARB, last modified August 9, 2021, available at <https://ww2.arb.ca.gov/resources/documents/lcfs-pathway-certified-carbon-intensities>.

As a carbon-negative technology, RNG-fueled trucks compare favorably to plug-in battery electric trucks fueled by grid electricity, which had a CI of +75.93 gCO<sub>2</sub>e/MJ.<sup>36</sup> In fact, a CARB comparison of the carbon intensities of key clean transportation fuels shows that RNG produced high solid anaerobic digestion (HSAD), gasification, and dairy have a lower CI than electricity.

Disincentivizing immediate transition to RNG trucks encourages continued operation of HD diesel trucks that cause 50 percent of California's smog-precursor emissions.<sup>37</sup> Ramboll's analysis [included below as Attachment 1] indicates that "transitioning to Optional Low-NO<sub>x</sub> RNG trucks today can reduce GHG emissions more quickly and cost-effectively as compared to BE trucks (which should be seen as long-term solutions for many duty-cycles), while also improving local air quality more quickly per dollar invested."<sup>38</sup> Notably, the CEC's Natural Gas Research and Development Program funded these Low-NO<sub>x</sub> Cummins engines.

Furthermore, the analysis indicates that switching to Optional Low-NO<sub>x</sub> RNG heavy, heavy-duty (HHD) trucks is more cost effective to obtain needed GHG emissions reductions over the next decade, relative to the slower replacement of battery-electric (BE) trucks. Table 10 of Ramboll's Analysis highlights the potential emissions reductions from \$1 Billion of investment into MY 2024 Class 8 HHD trucks through an evaluation of the potential GHG, black carbon, and NO<sub>x</sub> emissions reductions that can be achieved with the investment. The evaluation concludes that an investment of this size would generate approximately "3.1 times more black carbon reductions, 2.8 times more lifecycle GHG reductions, and 2.9 times more tailpipe NO<sub>x</sub> reductions in comparison to the equivalent investment in [BE] trucks."<sup>39</sup> Please note that Ramboll's evaluation has not accounted for the cost and time of implementation regarding the expanded electricity generation, transmission, and distribution needed for BE trucks,<sup>40</sup> which presumably would increase the costs for BE trucks relative to Low-NO<sub>x</sub> RNG HDD trucks.

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<sup>36</sup> See "Low Carbon Fuel Standard Annual Updates to Lookup Table Pathways," CARB, March 15, 2021, p.2.

<sup>37</sup> Game Changer Report, April 2016, available at [https://ngvgamechanger.com/pdfs/GameChanger\\_FullReport.pdf](https://ngvgamechanger.com/pdfs/GameChanger_FullReport.pdf).

<sup>38</sup> See Attachment 1 below, Ramboll Memorandum on the 'Comparison of Lifetime Emissions and Cost-Effectiveness of Class 8 Heavy-Duty Truck Technologies,' at p. 6.

<sup>39</sup> *Ibid.*

<sup>40</sup> *Ibid.*

## Appendix B: Ensuring Energy Reliability

### **4. Blackouts from heatwaves and yearly outages during Public Safety Power Shutoff (PSPS) events are downplayed in the draft to the detriment of ensuring a reliable electric grid.**

On page 7 of Volume II, Ensuring Reliability in a Changing Climate, states the following: “On August 14–15, 2020, an extreme heat event resulted in rotating outages in the California Independent System Operator (California ISO) territory. While customers lost power for only 20–60 minutes...” We respectfully request for the CEC to cite this dataset as it contradicts other datasets. For example, the San Diego Union Tribune reported “on Aug. 14, [2020], 491,600 electricity customers of California’s three big investor-owned utilities — San Diego Gas & Electric, Southern California Edison and Pacific Gas & Electric — lost power between 6:30 p.m. and 7 p.m. for anywhere between 15 minutes to 2 1/2 hours. The next evening 321,000 customers statewide were cut off, with downtimes ranging from eight to 90 minutes.”<sup>41</sup> Given that this was the first time California had to involuntarily shut down power since the energy crisis 20 years ago, the discussion in the Draft IEPR on the blackouts seems to downplay the significance of such events, especially to the economy. Critical facilities may experience significant loss or hardship if their operations are impacted by an outage. For example, manufacturing processes or data centers can suffer significant financial hardships for just minutes without power.<sup>42</sup>

Additionally, according to Bloom Energy “Power outages are on the rise in California. There were approximately 25,281 blackout events in 2019, a 23% increase from 20,598 in 2018. The number of utility customers affected jumped to 28.4 million in 2019, up 50% from 19 million in 2018.”<sup>43</sup> Blackouts can be traditionally interpreted as a rural problem, however, data by Bloom Energy indicates that larger cities (urban) in California could face a higher risk of blackout events and more customers impacted.<sup>44</sup> We respectfully suggest for the CEC to fund clean distributed generation like fuel cells through the Electric Program Investment Change (EPIC) Program to help reduce the proliferation of diesel BUGs (as discussed above) to the public health benefit of all ratepayers.

While electric utilities report total outages and customer classes affected to regulators annually, it is difficult to manage accurate tracking of day-to-day blackout occurrences within the State and assess outage impacts. To analyze regional trends of the total outage hours and the impacts on customer classes, SoCalGas evaluated the California Public Utilities Commission (CPUC) data on PSPS events among the four electric utilities, including PacifiCorp, Pacific Gas & Electric

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<sup>41</sup> See Nicolewski, Rob, “Report: A combination of factors caused California’s rolling blackouts in August,” San Diego Tribune, October 7, 2020, available at: <https://www.sandiegouniontribune.com/business/story/2020-10-07/report-a-combination-of-factors-led-to-californias-rolling-blackouts-in-august#>.

<sup>42</sup> See “A Day Without Power: Outage Costs for Businesses” Bloom Energy, October 9, 2009, available at <https://www.bloomenergy.com/blog/a-day-without-power-outage-costs-businesses>.

<sup>43</sup> See California Power Outage Map, Bloom Energy, available at <https://www.bloomenergy.com/bloom-energy-outage-map/>.

<sup>44</sup> *Ibid.*

(PG&E), Southern California Edison (SCE), and San Diego Gas & Electric (SDG&E).<sup>4546</sup> We showcase a subset of 17 circuits located in Riverside County because CAL FIRE has designated Riverside County as a Very High Fire Hazard Severity Zone, and community members have unique local responsibilities as they belong to a high hazard zone.<sup>47</sup> Figure 1 (below) shows approximately 268 incidents on the 17 circuits in Riverside County from October 2019 to January 2021.<sup>48</sup> Total outages hours range from 111 hours to 752 hours, which is equivalent to approximately 4.5 days to 31 days without power cumulatively. Such increases in power outages are correlated to diesel BUGs usage growing at a rapid pace in California with enough capacity to power 15 percent of the electric grid (as further discussed above).<sup>49</sup>

Figure 2 (below) shows the cumulative number of customers impacted, separated by customer class (residential, commercial/industrial, or medical baseline) in each circuit. As discussed above, the growing reliance on diesel BUGs undermines efforts made by the State regarding climate change mitigation, air quality attainment requirements, among others. Additionally, SoCalGas is currently working with the Gas Technology Institute (GTI) to specifically develop a residential fuel cell for commercialization and widespread deployment in California. We recommend the Energy Commission explore the high PSPS event circuits for the entire state to identify areas that could benefit from clean and reliable microgrid solutions like fuel cells powered by the existing resilient natural gas network.

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<sup>45</sup> See Utility Company 2021 and 2020 PSP Post Event Reports, ‘CPUC PSPS Rollup October 2013 through October 2021, available at <https://www.cpuc.ca.gov/consumer-support/psps/utility-company-psps-post-event-reports>.

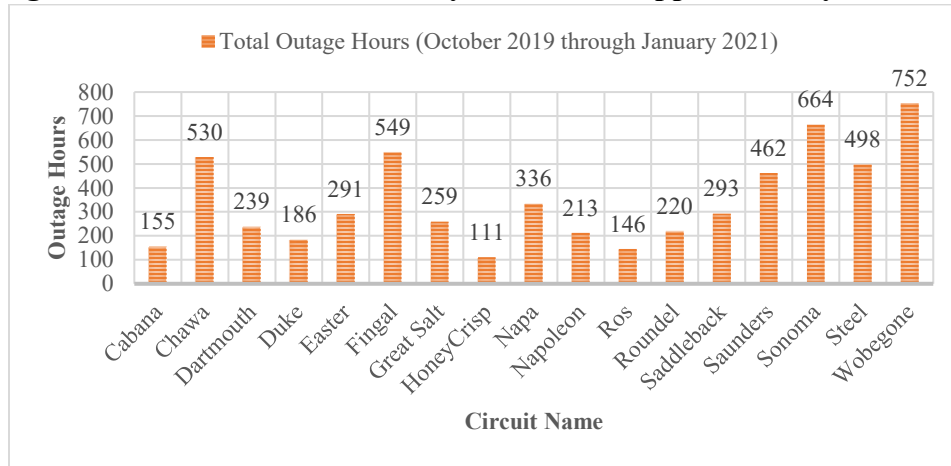
<sup>46</sup> SoCalGas chose a random sample of 50 circuits within SCE’s service territory, as there is significant overlap with SoCalGas’ service territory.

<sup>47</sup> See Fire Hazard Severity Zones Maps, Office of the State Fire Marshall, available at <https://osfm.fire.ca.gov/divisions/wildfire-planning-engineering/wildland-hazards-building-codes/fire-hazard-severity-zones-maps/>.

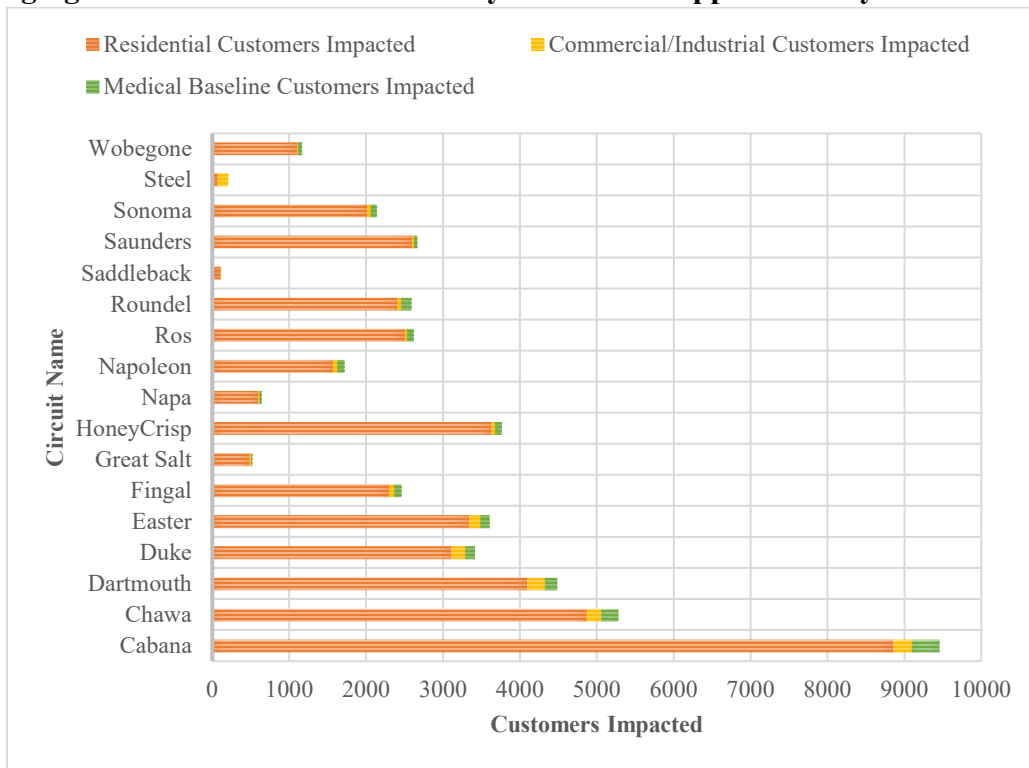
<sup>48</sup> Please note that according to SCE, there are approximately 501 total SCE circuits in Riverside County. We acknowledge that we have only analyzed 17. See Circuit List by Community – Riverside County, Southern California Edison, available at <https://www.sce.com/wildfire-resource-repository>.

<sup>49</sup> See “The Diesel-Fired California Dream,” California Energy Markets, October 8, 2021, No. 1662, available at [https://www.newsdata.com/california\\_energy\\_markets/bottom\\_lines/the-diesel-fired-california-dream/article\\_f65b1070-2876-11ec-b3f1-f3ef2c8a4076.html](https://www.newsdata.com/california_energy_markets/bottom_lines/the-diesel-fired-california-dream/article_f65b1070-2876-11ec-b3f1-f3ef2c8a4076.html).

**Figure 1: Total Outage Hours for 17 Selected SCE Riverside County Circuits for Period Ranging from October 2019 to January 2021 across approximately 268 incidents<sup>50</sup>**



**Figure 2: Impacted Customers Within 17 SCE Riverside County Circuits for Period Ranging from October 2019 to January 2021 across approximately 268 incidents<sup>51</sup>**



<sup>50</sup> The random sample of 17 circuits located in Riverside County for this analysis were selected from the cumulative list of circuits contained on the CPUC PSPS Event Data Found Webpage, available at <https://www.cpuc.ca.gov/consumer-support/pssp/utility-company-pssp-post-event-reports>.

<sup>51</sup> *Ibid.*



**5. Energy trends in California and across the West warrant conservative assumptions regarding the availability of imports and hydroelectric power to create a clean, reliable, and resilient interdependent California energy system.**

In a past IEPR workshop, both the California Independent System Operator (CAISO) and panelists noted that the availability of net imports is decreasing as the net load increases, becoming more pronounced during July through September.<sup>52</sup> Extreme weather events experienced throughout the West coupled with ambitious decarbonization goals extending outside California compel serious consideration and trepidation about the reasonableness of the State's continued reliance on imports. These market and regional dynamics necessitate a deeper examination of the appropriate operational mix of resources California load serving entities (LSEs) need to meet the reliability demands of an evolving and increasingly clean energy system. Given the changing landscape for imports and hydro power, we suggest that the Draft IEPR use conservative modeling assumptions around the availability of imports and hydropower as necessary and appropriate to avoid unanticipated shortfalls. In turn, we suggest recommendations in the Draft IEPR support investments needed in-state to wean LSEs from their dependence on imports and make certain a robust supply of firm, dispatchable generation is available and ready to meet increasing in-state demands on the system.

California has historically been a net electricity importer, with about 30 percent of energy needs supplied by imports on a net annual basis, typically with more imports during California's daily net system peak.<sup>53,54</sup> As supply and demand changes over the western region, however, a drop in the availability of imports particularly over the net high load conditions is becoming an emerging trend concerning both the CAISO as well as LSEs who rely on imports for critical energy and resource adequacy during times when renewables are unavailable. While panelists identified greater levels of transparency and regionalization as efforts needed to increase supply, they agreed that such measures are likely to provide limited relief.<sup>55</sup> As more states across the West decarbonize, the need for firm, dispatchable power is becoming more acute, with scarcity around supply driving higher prices and leading to resource shortfalls. The situation is compounded by a changing resource mix in-state resulting in limited supplies of firm dispatchable generation. As a result, SCE identified a critical contributing factor to increased outage rates given the increased reliance of in-state gas generation units.<sup>56</sup> These in-state gas fired units are being pushed to their

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<sup>52</sup> See CEC IEPR Joint Agency Workshop on Summer 2021 Reliability, Session 1: Hydro Resources and the Drought, available at <https://www.energy.ca.gov/event/workshop/2021-07/iepr-joint-agency-workshop-summer-2021-electric-and-natural-gas-reliability>.

<sup>53</sup> See 2020 Total System Electric Generation, Michael Nyberg, webpage available at: <https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2020-total-system-electric-generation>.

<sup>54</sup> See CAISO Today's Outlook: Daily Supply Trend, available at <http://www.caiso.com/TodaysOutlook/Pages/supply.html>.

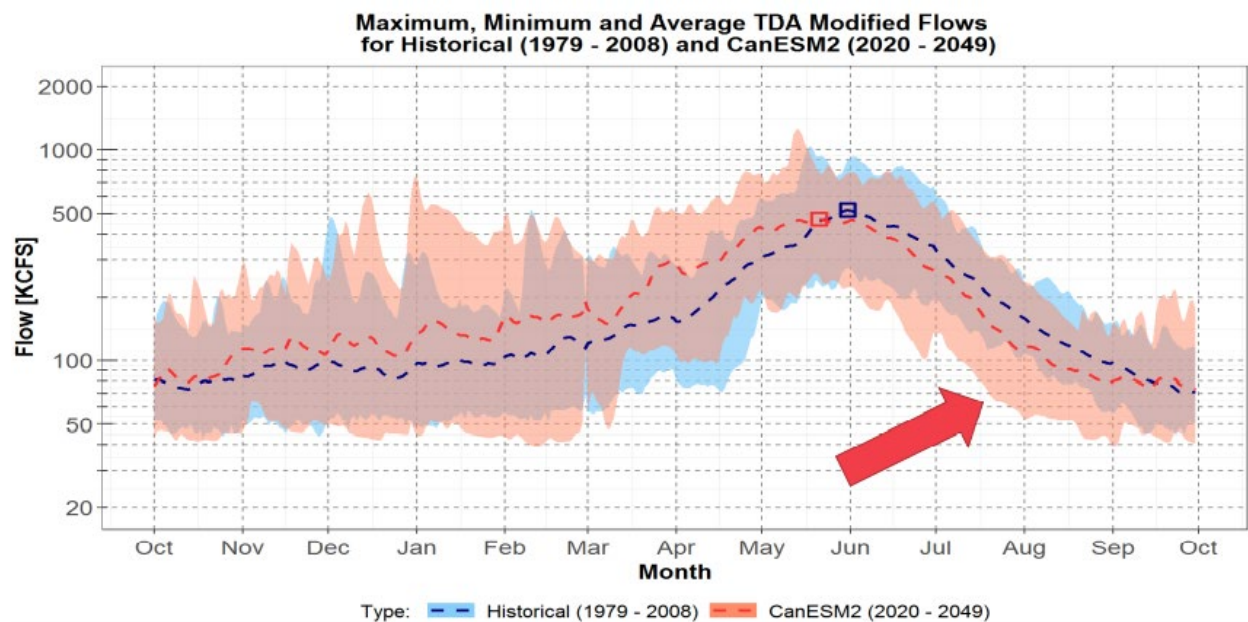
<sup>55</sup> See IEPR Joint Agency Workshop on Summer 2021 Reliability, Session 2: Imports, Demand Response, and Multi-Year Outlook, available at <https://www.energy.ca.gov/event/outreach/2021-07/iepr-joint-agency-workshop-summer-2021-electric-and-natural-gas-reliability>.

<sup>56</sup> See SCE comments on the CEC's IEPR Workshop, July 23, 2021, available at: <https://efiling.energy.ca.gov/getdocument.aspx?tn=238993>.

operational limits throughout the year and foregoing routine maintenance in April or October to continue supporting the electric grid.

California’s energy system is complicated (and becoming more so), increasingly convergent and interdependent. As CEC Vice Chair Gunda and CAISO President Mainzer noted, California tends to “live right on the edge” or “margin” when managing the reliability of our electric system.<sup>57</sup> In SoCalGas’ May 18 letter to the CEC on Summer 2021 Reliability,<sup>58</sup> we noted that climate change is diminishing hydro’s traditional ability to support the electric grid, especially through the decreased seasonal storage capacity of snowpack. Hotter temperatures cause rain to fall in the winter, rather than snow, and dams must release this excess water in the Spring. In Session 1, Northwest Power & Conservation Council confirmed this point by presenting historical and projected data. As seen in Figure 3, January through May shows hydropower projections well above historical averages due to high rainfall in those months and less hydro power available in the hottest months from June to September.<sup>59</sup>

**Figure 3: Historic versus Projected Hydro Flows**



The lack of hydro resources during the hottest months is a significant driver of the system being on “the edge” and it will continue to get worse. It is worth noting these are not new issues as the CEC and CPUC identified the need for bulk, long duration storage and held a Joint Workshop in 2015 to identify barriers and develop recommendations.<sup>60</sup> The resultant staff paper proposed five

<sup>57</sup> See IEPR Joint Agency Workshop on Summer 2021 Reliability, Session 2: Imports, Demand Response, and Multi-Year Outlook.

<sup>58</sup> See SoCalGas Comments on Summer 2021 Reliability, May 18, 2021, available at: <https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=21-IEPR-04>.

<sup>59</sup> See CEC IEPR Joint Agency Workshop on Summer 2021 Reliability, Session 1: Hydro Resources and the Drought.

<sup>60</sup> See Joint California Energy Commission and California Public Utilities Commission Long-Term Procurement Plan Workshop on Bulk Energy Storage, docket 15-MISC-05, Notice of Workshop is TN #206535 and Agenda of

recommendations to help increase capacity and capabilities of bulk energy storage.<sup>61</sup> Their recommendations were as follows: 1) valuation of pumped hydro as a grid support service for fast ramping capabilities of variable speed pumps as well as local supply during transmission failures, 2) organizing a Bulk Storage User Committee, 3) streamlining licensing of hydroelectric projects, 4) developing a cost-benefit study of the value of location-specific storage, and 5) facilitating joint ventures to overcome the significant upfront capital costs.<sup>62</sup> Where future hydroelectric projects may be difficult in the current environmental climate, many of the same principals identified could be used in hydrogen storage projects which also are capital intensive projects.

Climate policies are also shaping the market for how much hydropower is available both in and out-of-state. Hydroelectric generation from large facilities does not receive Renewable Portfolio Standard credit. Generation from small hydro facilities qualifies for Renewable Portfolio Standard (RPS) credits but competes on a levelized cost of generation basis with solar photovoltaic resulting in existing hydro resources being decommissioned. Stanford's Bill Lane Center for the American West published an article, *As Relicensing Looms, Aging Dams Face a Reckoning*, highlighting this challenge.<sup>63</sup>

Hydroelectric licenses tend to be for 30 to 50 years, with many dams throughout the West up for relicensing in the 2015 to 2025 timeframe. For economic and environmental reasons, owners are forgoing the option to relicense. PG&E chose not to seek relicensing for several facilities, and if no one steps forward to run the facilities, PG&E will be compelled to develop a decommissioning plan. Because large hydro generation does not qualify for RPS support, portions of its capacity are unable to attract long-term contract arrangements. Data centers migrated to locations with an excess hydroelectric supply like the Pacific Northwest and Quebec. A Politico Magazine article from 2018 stressed that digital currency mining would “suck up so much of the power surplus that is currently exported...”<sup>64</sup> As a result, data centers capitalizing on low-cost hydroelectric generation from large hydro facilities from out-of-state has resulted in less export potential to California.

## **6. California's electricity grid increasingly relies on diminishing gas-fired generation capacity to ensure energy system reliability.**

The ability to provide just-in-time fuel to the electric grid during times of high demand while also facilitating quick ramp downs when needed is an operational feature anticipated to be in even greater demand as LSEs make progress towards SB 100 goals and greater parts of the California

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Workshop is TN #206690, available at <https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=15-MISC-05>.

<sup>61</sup> See CEC, Bulk Energy Storage in California, authors Collin Doughty, Linda Kelly, John Mathias, July 2016, CEC-200-2016-006, available at <https://www.energy.ca.gov/sites/default/files/2021-06/CEC-200-2016-006.pdf>.

<sup>62</sup> *Ibid.*

<sup>63</sup> Felicity Barringer, “As Relicensing Looms, Aging Dams Face a Reckoning,” Stanford University, The Bill Lane Center for the American West, 2019, available at <https://west.stanford.edu/news/blogs/and-the-west-blog/2019/green-power-source-or-fish-killer-relicensing-looms-aging-dams-face-reckoning>.

<sup>64</sup> Paul Roberts, “This is What Happens When Bitcoin Miners Take Over Your Town,” Politico Magazine, March/April 2018, available at <https://www.politico.com/magazine/story/2018/03/09/bitcoin-mining-energy-prices-smalltown-feature-217230/>.

economy electrify. On page 33 of Volume II, the Draft IEPR notes that almost 13,000 MW of once-through-cooling (OTC) capacity has retired.<sup>65</sup> This includes about 11,000 MW of gas-fired generation and 2,000 MW of nuclear capacity. Despite this decline in capacity, gas throughput to support dispatchable electric generators (DEGs) continues to rise. For example, in 2020, in significant measure most peak hour gas deliveries from SoCalGas' system were to serve DEGs and electric system ramping needs more so than to serve peak hour core customer thermal load.<sup>66</sup> For example, of the 77 hours in 2020 when deliveries to either core customers or DEGs exceeded 100,000 Dekatherms/hour (Dths/hr) (equivalent to ~ 2.4 billion cubic feet/day (Bcf/d) of capacity), 62 hours were to serve DEGs while 15 hours served core customers.<sup>67</sup> In 2021, the peak hour gas deliveries to DEGs exceed the peak hour for 2020. Our modeling projects this trend to continue and is likewise consistent with the CPUC projections.

Further, Volume II notes that “[gas plants] have proven necessary to fill in when renewable resources are not available. However, gas plants have their own reliability issues. These systems often operate at less-than-rated maximum capability during extreme heat events, when demand is high and like any mechanical equipment, they have system failures, causing them to shut down for maintenance. Operators work to keep them maintained during lower-demand periods of the year, but systems can break down during prolonged and heavy heat events.”<sup>68</sup> It is worth restating that during the Summer 2021 reliability workshops, it was noted that due to the region-wide impact of climate change and renewables deployment, the remaining in-state gas fired units are being pushed to their operational limits throughout the year and foregoing routine maintenance in April or October to continue supporting the electric grid.<sup>69,70</sup> We request that the CEC clarify this point in the report and properly analyze the implications, including that a diminishing fleet of gas resources are being taxed year-round to increasingly support the electric system's reliability needs and what this means for long-term energy planning, especially during heatwaves.

## **7. Data points indicate the need for long duration storage.**

Volume II of the IEPR acknowledges the need for long-duration storage. As indicated above in bullet point 5, the reduction of hydropower later in the year during high electricity peaks will drive up the need for new energy resources at that time. Another data point worth considering in the analysis of long duration storage needs is highlighted in the Energy Commission's Thermal Efficiency of Natural Gas-Fired Generation in California: 2019 Update.<sup>71</sup> Figure 4 shows the average generation profiles for the aging hourly generation fleet by season. For 9 months out of the year, the older, less efficient power plants remain idle, but during the peak electricity months

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<sup>65</sup> See 2021 Draft IEPR, Volume II, pg. 33.

<sup>66</sup> SoCalGas' internal modeling analysis.

<sup>67</sup> *Ibid.*

<sup>68</sup> See 2021 Draft IEPR, Volume II, pg. 30.

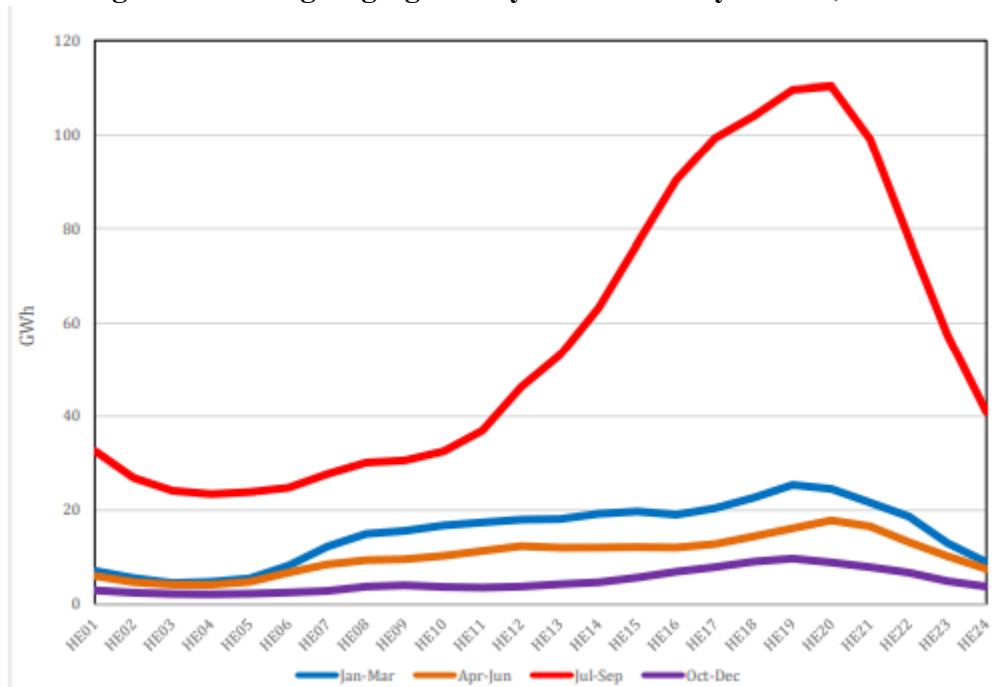
<sup>69</sup> *Ibid.*, IEPR Summer 2021 Reliability.

<sup>70</sup> During the CEC IEPR Summer Reliability Workshop, Session 2, Marci Palmstrom, SCE, stated, “Normally, we see facilities take outages in the April... and October timeframe so that they can do maintenance to their facilities and be ready for the summer. We're seeing that there's just less opportunity because they are needed in those months.”

<sup>71</sup> CEC Staff Paper, *Thermal Efficiency of Natural Gas-fired Generation in California: 2019 Update*, Michael Nyberg, June 2020, CEC-200-2020-03.

of summer they ramp up to provide power especially during hours 4 pm through 10 pm. Batteries would not be an ideal resource to replace this seasonal capacity, because their cost-effectiveness relies on being used often.

**Figure 4: Average Aging Hourly Generation by Season, 2018<sup>72</sup>**



Volume II has a very interesting chart (Figure 8) that showcases the renewable doldrum period of solar and wind combined generation. Combinations of solar and wind in mid-September, mid-March, and mid-June are relatively consistent. However, the combined generation profile dips fairly remarkably in mid-December. As thermal loads electrify and some peak electricity load times begin to occur during the winter months, it will be important to have an adequate supply of seasonal storage to help fill those long terms gaps.

We request the IEPR includes a recommendation to look more closely at very long duration (seasonal) storage needs and quantifies a capacity need for energy planning purposes.

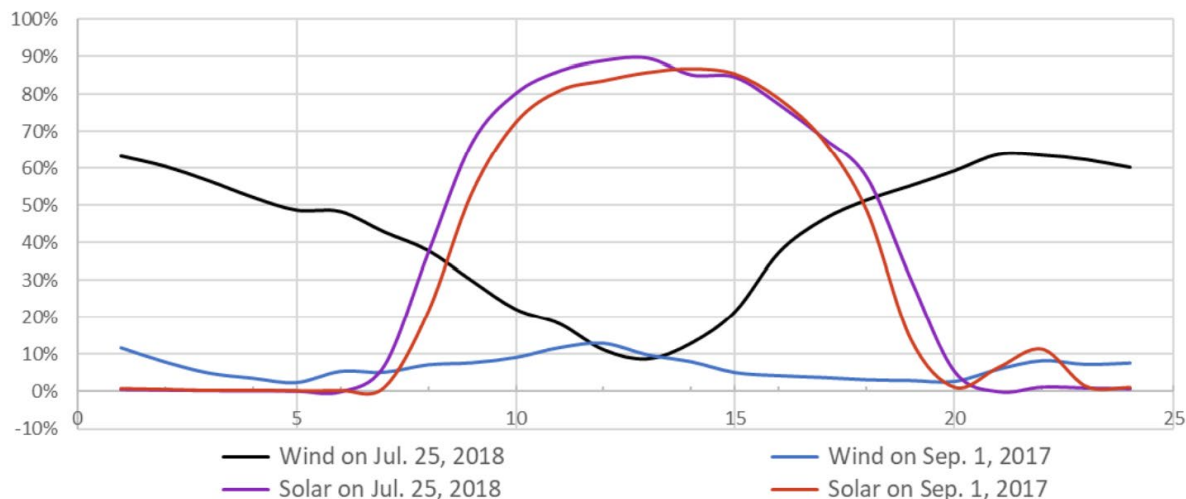
**8. High temperatures lessen the operational efficiencies of all electricity generation and transmission assets.**

As noted above, Volume II focuses only on the performance issues during heatwaves from a diminishing gas fleet that is being taxed year-round to support the electric grid. We respectfully suggest that the IEPR report reflect how the operational efficiencies of electricity generation and transmission assets are impacted by high temperatures. The declining operational efficiency of

<sup>72</sup> Ibid., figure 6 at p. 23.

solar during high temperatures<sup>73</sup> is shown in Figure 6 and Figure 7 in Volume II of the Draft IEPR.<sup>74,75</sup> [Figure 7 from the 2021 Draft IEPR is reproduced herein as Figure 5.] During peak days in 2017 and 2018, solar output never exceeded 90 percent capacity.

**Figure 5: Wind and Solar Profiles by Hour on Peak Days in 2017 and 2018<sup>76</sup>**



Similarly, research published in a 2016 Environmental Research Letter notes that impacts of rising air temperatures reduce capacity of transmission lines and increase peak electricity loads. Researchers found that climate change could cause transmission capacity reductions between 2 percent and 6 percent depending on the climate scenario.<sup>77</sup> This is further substantiated in a figure [reproduced as Figure 6 below] from a March 2021 report by the Government Accountability Office, which notes warmer temperatures reduce the capacity of generation sources and transmission lines.

<sup>73</sup> Renvu calculates the energy loss from solar PV as the temperature minus Standard Test Condition temperature of 25 degrees C times the Pmax Temperature Coefficient of negative 0.43. An example is solar panels in 45 degree C or 113-degree F for a difference in temperature of 20 degrees C times negative 0.43 for an efficiency loss of 8.6 percent. See website at <https://www.renvu.com/How-Temperature-Affects-Solar-Panel-Efficiency>.

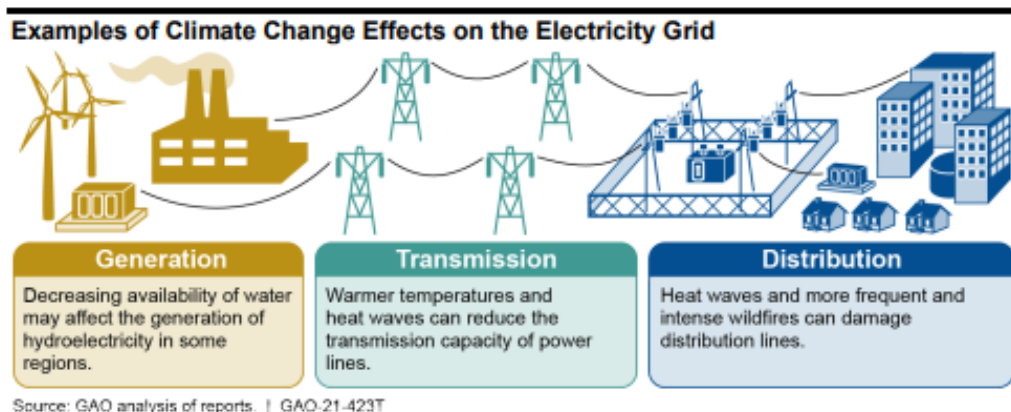
<sup>74</sup> See 2021 Draft IEPR, Volume II, Figure 6, pg. 24.

<sup>75</sup> See 2021 Draft IEPR, Volume II, Figure 7, pg. 25.

<sup>76</sup> *Ibid.*

<sup>77</sup> Matthew Bartos et al, Environmental Research Letter 11, November 2, 2016, available at <https://iopscience.iop.org/article/10.1088/1748-9326/11/11/114008>.

**Figure 6: GAO Overview of Impacts on Generation, Transmission, and Distribution Pertaining to the Electric Grid<sup>78</sup>**



**9. The evolving electricity system’s increasing reliance on transmission creates challenges.**

On page 46 of Volume II, the Draft IEPR states that “[r]isks on In-State Transmission Paths Fires can occur in any part of the state, and most transmission outside urban areas pass through high fire-risk areas.<sup>79</sup> The CPUC has identified fire-threat areas that span from the northernmost to the southernmost areas of the State, which could result in transmission pathways that need to traverse the high-risk areas or need exceptional undergrounding to reach California’s major load centers.<sup>80,81</sup> As more renewables come online, California’s electricity system is increasingly becoming more and more reliant on transmission infrastructure. As such, we suggest the Draft IEPR acknowledge the changing energy supply system (decommissioning supply near load and increasing supply far from load) will result in more need for transmission lines than would ultimately be needed if we built a system where supply is located near load.

The State’s electricity system was built to generate as much electricity near load as possible. Populations tend to be near the coast, with many of the power plants constructed nearby using ocean water as the cooling system. However, the State Water Board’s once through cooling policy has required that some of these power plants shut down and some repowered. Furthermore, renewable generation has reduced the number of operational hours from the gas-fired power plant fleet, so more and more of the kWhs are generated outside the local capacity areas. Wind, solar and geothermal resources need adequate space, good resources and, in the case of geothermal, is only in a few locations. Therefore, State supply resources are moving further away from load and will rely on transmission to deliver the power to load pockets.

<sup>78</sup> See Electricity Grid Resilience, climate Change is Expected to Have Far-reaching Effects and DOE and FERC Should Take Actions, Government Accountability Office, GAO-21-346, March 2021, pg. 2, available at: <https://www.gao.gov/assets/gao-21-346.pdf>.

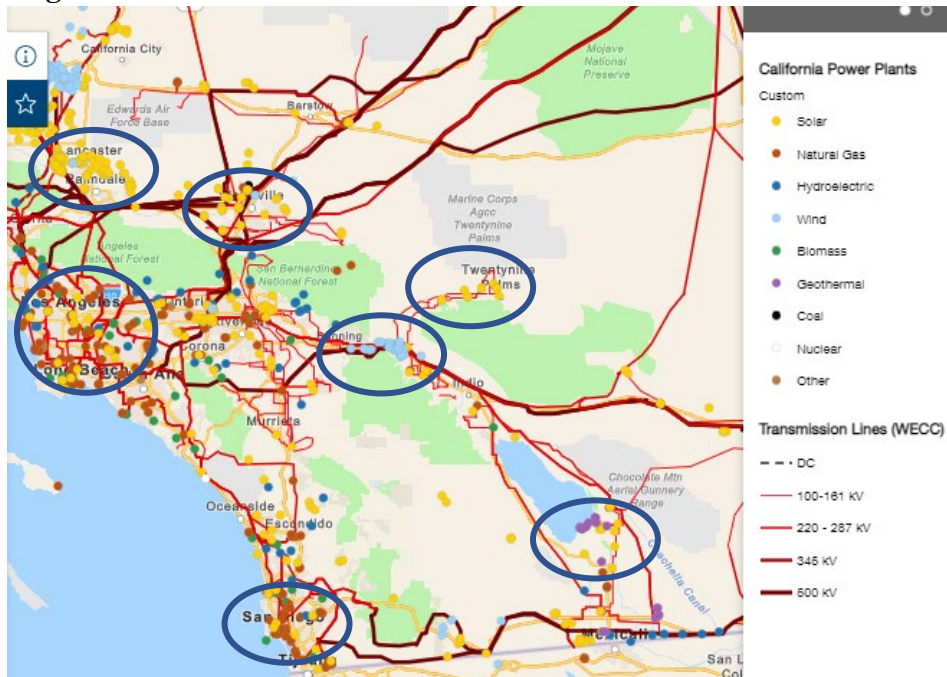
<sup>79</sup> See 2021 Draft IEPR, Volume II, pg. 46.

<sup>80</sup> See “Fire-Threat Maps and Fire-Safety Rulemaking,” CPUC, available at <https://www.cpuc.ca.gov/industries-and-topics/wildfires/fire-threat-maps-and-fire-safety-rulemaking>.

<sup>81</sup> See “CPUC FireMap,” CPUC, available at [https://cpuc\\_firemap2.sig-gis.com/](https://cpuc_firemap2.sig-gis.com/).

This phenomenon is evident in Figure 7, which is a map of California power plants in southern California.<sup>82</sup> While it is somewhat hard to read and it doesn't show the magnitude of the power plants, the geospatially located dots of solar and wind tend to be in low populated areas connected to long transmission lines, while the natural gas power plants tend to be located near the population centers.

**Figure 7: Southern California Power Plants and Transmission Lines**



Further on page 3 of Volume II, the Draft IEPR states: “[w]est-wide heat events and wildfires can reduce access to electricity from neighboring states because of greater competition for electricity in those states and because wildfires may impact transmission lines that bring critical power into California.”<sup>83</sup> Building off the previous discussion, we suggest adding language to include the risks of access to remote renewable power. Specifically, we recommend the following language change to the Draft IEPR in Volume II, page 3: “[w]est-wide heat events and wildfires can reduce access to electricity from neighboring states as well as instate renewables because of greater competition for electricity in those states and because wildfires may impact transmission lines that bring critical power into California as well as deliver power from outside load pockets to the load centers.”

<sup>82</sup> See California Energy Commission’s California Electric Infrastructure App, available at: <https://cecgis-caenergy.opendata.arcgis.com/apps/california-electric-infrastructure-app/explore>.

<sup>83</sup> See 2021 Draft IEPR, Volume II, pg. 3.



**10. The Draft IEPR should acknowledge that delays in projected battery storage deployment could continue.**

The CEC Midterm Reliability Analysis includes a scenario that addresses some concerns about being able to procure batteries at sufficient quantities in time for procurement needs.<sup>84</sup> This scenario uses an assumption of 20 percent delays which could be attributed to supply chain, permitting, and/or construction issues, yet does not cite the source for this optimistic scenario. Rather, there is evidence to suggest that battery storage delays could be closer to 50 percent. The CAISO, CPUC, and CEC’s Root Cause Analysis of the August 2020 blackouts states: “CPUC jurisdictional LSEs have already begun procurement of new capacity that will be online by summer 2021...this includes NQC values of approximately 2,100 MW of storage and hybrid storage resources.”<sup>85</sup> Volume II of the Draft IEPR reports that roughly 550 MW of battery storage was online at the end of 2020 and 1,500 MW of storage was online by September 2021.<sup>86</sup> There was therefore only a net increase of 950 MW of battery storage online by the summer of 2021, where the Joint Agencies procured and assumed 2,100 MW would be online. We suggest the Draft IEPR reference that delays of 20 percent do not reflect current procurement rates and could be underestimating the future delays of battery storage.

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<sup>84</sup> See “CEC Staff Report Midterm Reliability Analysis,” CEC, September 2021, pg. A-37, available at <https://www.energy.ca.gov/sites/default/files/2021-09/CEC-200-2021-009.pdf>.

<sup>85</sup> “Preliminary Root Cause Analysis: Mid-August 2020 Heat Storm,” CAISO, October 6, 2020, page 64, available at <http://www.caiso.com/Documents/Preliminary-Root-Cause-Analysis-Rotating-Outages-August-2020.pdf>.

<sup>86</sup> See 2021 Draft IEPR, Volume II, pg. 26.

## Appendix C: Conserving Resources

### **11. Load-shifting technologies should be deployed for gas appliances to conserve energy and serve as reliable back-up power to complement Grid-interactive Efficient Buildings (GEBs)**

Recently, the U.S. DOE Office of Fossil Energy and Carbon Management (FECM) announced the intent to fund the development of a Natural Gas Demand Response (DR) Pilot Program. Following the success of demand response programs in electricity markets, the FECM’s Natural Gas DR Pilot Program aims to replicate that success in natural gas systems at a national level.<sup>87</sup> Natural Gas DR would bring the same level of interactivity to the gas system as the current capability on the electric grid. We suggest the Draft IEPR support that the development of smart technologies for natural gas appliances which can lead to increased energy efficiency and savings for California ratepayers.

The presence of smart gas appliances in heavily electric buildings integrates an additional energy source as a back-up to electricity. As evidenced by the Alabama Power’s Smart Neighborhood example—which combines approximately 62 high-performance homes and a microgrid shared by the community<sup>88</sup>—natural gas utilities can provide similar back-up power sources for GEB community projects. Such back-up power sources would most likely improve the load-shifting technology value proposition, especially in areas prone to wildfires or PSPS events. According to the National Association of State Energy Officials (NASEO): “there can be GEB-pertinent interactions, such as peak demand reduction and grid-services that can be supplemented through an onsite fuel-consuming generation, such as fossil-fueled combined heat and power (CHP) and microgrids.”<sup>89</sup> In addition, NASEO acknowledges that “electricity and onsite fuel use interact in certain systems, such as electric loads from fans distributing heat from fuel-burning furnaces.”<sup>90</sup>

There is also potential to achieve energy savings by adopting smart technologies for natural gas appliances. Historically, it was not possible to connect tank water heaters that were lacking a connection to the electric grid to smart devices. Smart water heater controllers are available to address this technological limitation.<sup>91</sup> These devices enable users to set their water heater, so it runs to match their daily schedule and vacations, saving energy during idle periods. Some retrofittable smart water heater controllers are compatible with both gas and electric water heaters. There are many smart devices available on the market with similar capabilities. Smart devices that work for both gas and electric appliances present an opportunity to provide additional functionality

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<sup>87</sup> “U.S. DOE Natural Gas Demand Response Pilot Program,” U.S. DOE FECM, August 6, 2021, available at <https://www.energy.gov/fecm/articles/doe-announces-intent-fund-development-natural-gas-demand-response-pilot-program>.

<sup>88</sup> “The First Smart Neighborhood of Its Kind in the Southeast,” U.S. DOE EERE, June 13, 2021, available at <https://www.energy.gov/eere/buildings/articles/first-smart-neighborhood-its-kind-southeast>.

<sup>89</sup> “Grid-interactive Efficient Buildings: State Briefing Paper,” NASEO-NARUC Grid-interactive Efficient Buildings Working Group, available at <https://naseo.org/data/sites/1/documents/publications/v3-Final-Updated-GEB-Doc-10-30.pdf>.

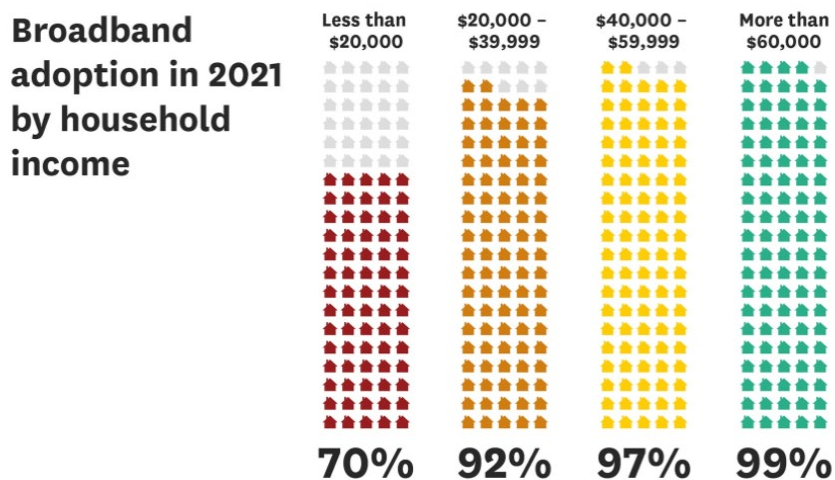
<sup>90</sup> *Ibid.*

<sup>91</sup> See e.g., Aquanta, available at <https://aquanta.io/>.

to drive consumer behavior towards conservation and energy efficiency. Additional functionality on gas appliances allows for real-time augmentation of gas usage in the event of a system curtailment. SoCalGas estimates there were approximately 300 DR-enabled residential water heaters in its service territory in 2018.<sup>92</sup> This is a very low penetration rate compared to the roughly 4 million residential customers in SoCalGas’ service territory that year.<sup>93</sup>

Whether using gas or electric appliances to conserve energy, we suggest that additional consideration also be given to the digital divide in California, especially when planning for the deployment of GEBs. Interconnectivity of devices rely on broadband or a Wi-Fi connection. Research estimates that approximately 1.3 million Californians do not have access to a wired internet connection capable of less than or equal to 25 megabits per second of download speeds,<sup>94</sup> which is a minimum requirement to conduct standard web browsing.<sup>95</sup> Moreover, approximately 890,000 California residents do not have access to wired internet providers within their region.<sup>96</sup> Figure 8 (below) reveals that California households with an annual household income of less than \$20,000 have the lowest adoption rate of broadband, relative to all other household income classes measured in the survey and therefore income was a vital indicator of whether a household has internet access.<sup>97</sup>

**Figure 8. California Broadband Adoption, Separated by Household Income levels<sup>98</sup>**



<sup>92</sup> See Southern California Gas Company DR Program, Prepared Testimony of Darren Hanway on behalf of Southern California Gas Company, p.12, November 6, 2018, available at [A.18-11-005 | SoCalGas](https://www.cpuc.ca.gov/natural_gas/).

<sup>93</sup> “Natural Gas and California,” CPUC. Available at [https://www.cpuc.ca.gov/natural\\_gas/](https://www.cpuc.ca.gov/natural_gas/).

<sup>94</sup> “Internet Access in California,” *BroadbandNow*, 2021, available at <https://broadbandnow.com/California>.

<sup>95</sup> David Anders, “Internet speed classifications: What counts as fast internet,” *AllConnect*, April 16, 2021.

Available at <https://www.allconnect.com/blog/internet-speed-classifications-what-is-fast-internet>.

<sup>96</sup> “Internet Access in California,” *BroadbandNow*, 2021.

<sup>97</sup> Ron MacKovich, “California surpasses 90% internet connectivity, but low-income households still lack access,”

*University of Southern California News*, March 30, 2021, available at: <https://news.usc.edu/183952/california-internet-access-usc-survey-broadband-connectivity/>.

<sup>98</sup> *Ibid.*

## **12. Targeting incentives towards non-energy barriers can increase the efficacy of energy conservation and decarbonization programs in disadvantaged communities.**

During the August 24, 2021 IEPR Workshop on the Role of Energy Efficiency in Building Decarbonization, CPUC Commissioner Houck highlighted that, while the State moves forward with our energy efficiency and decarbonization goals, it is important that we are not leaving the most vulnerable communities behind, who disproportionately live in older housing stock.<sup>99</sup> About 60 percent of California’s housing units were built before 1980.<sup>100</sup> Older homes contain physical barriers that increase the cost of implementing energy efficiency or weatherization programs. As we collectively pursue decarbonizing California’s energy system and our built environment, we suggest that the Draft IEPR take advantage of existing utility data to help target energy efficiency and decarbonization efforts in disadvantaged communities, while targeting target incentives to address non-energy barriers.

For example, a home may need costly electrical rewiring, reconfigured, or upgraded plumbing, or other physical alterations to accommodate a modern, high-efficiency appliance or to resolve a current issue like a hot water leak. Furthermore, many homes built before 1980 include asbestos containing materials, such as thermal and electrical insulation materials, ducting, wall board, and ceiling tiles that may require removal and containment prior to retrofitting heating and cooling systems including furnaces, air handlers, and vent systems.

Most funding for utility energy efficiency programs cannot be used to address non-energy barriers that inhibit the efficacy of energy efficiency programs. According to data collected from our SoCalGas Consumption Analytics Team, about 15 percent of the hot water leaks identified through SoCalGas’ Advanced Meter Program (AMP) in 2020 remained unresolved due to financial constraints and/or non-energy barriers. To effectively implement decarbonization and energy efficiency polices and help lower the energy burden in disadvantaged communities, the CEC could administer funding to utilities to assist CARE qualified customers in resolving non-energy barriers or to landlords housing CARE customers in making updates to their properties in a timely fashion.

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<sup>99</sup> See California Energy Commission IEPR Commissioner Workshop on the Role of Energy Efficiency in Building Decarbonization – The Importance of Energy Efficiency Held August 24, 2021 [Zoom Video File], available at [https://energy.zoom.us/rec/play/GLr0XuDtVs3PZfCgYMLPKtmhZgTUyPq2Uud0Lv6v6HY0wQmTQmNIs-mNUI\\_TdFlb\\_45iHJgQLVsvcBsg.QJpaclwwgAfbDok6?continueMode=true&\\_x\\_zm\\_rtaid=OwRe-5IUQkOeYrXCEey3PA.1630535258905.c5a51a992032c02b81be9ae90ad98caa&\\_x\\_zm\\_rhtaid=86](https://energy.zoom.us/rec/play/GLr0XuDtVs3PZfCgYMLPKtmhZgTUyPq2Uud0Lv6v6HY0wQmTQmNIs-mNUI_TdFlb_45iHJgQLVsvcBsg.QJpaclwwgAfbDok6?continueMode=true&_x_zm_rtaid=OwRe-5IUQkOeYrXCEey3PA.1630535258905.c5a51a992032c02b81be9ae90ad98caa&_x_zm_rhtaid=86).

<sup>100</sup> As of 2019, California has 14.367 million housing units. See U.S. Census, American Community Survey, 2019 1-year estimates data profiles. Table DP04, available at <https://data.census.gov/cedsci/table?q=california%20housing%20units&tid=ACSDP1Y2019.DP04>.

## Appendix D: Enhancing the State's Economy

### 13. State support for industrial hubs can help scale zero-carbon hydrogen and can provide a decarbonization pathway for high heat and energy-intensive industries.

Renewable hydrogen has the potential to play a critical role in California's zero-carbon economy. State policies and programs have the potential to support hydrogen infrastructure development and open the pathway to renewable hydrogen production becoming a self-sustaining zero carbon fuel source for California.<sup>101</sup> Initially focusing the development of hydrogen infrastructure toward industrial hubs creates opportunities for co-located industries to take advantage of scale, sharing risk and resources, aggregation and optimization of demand, cross-industry waste synergies, and other interdependencies.<sup>102</sup> Industrial hydrogen hubs can support energy diversity, improve energy resiliency (when using hydrogen fuel cells and above/below ground hydrogen storage), accelerate multi-sectoral decarbonization, drive down the cost of zero-carbon hydrogen, and create jobs.<sup>103</sup> California has already become a leader in the hydrogen industry with more hydrogen fueling stations than any other state in America.<sup>104</sup> With the city of Los Angeles aiming to reduce GHGs to 73% below 1990 baseline levels by 2035,<sup>105</sup> hydrogen infrastructure initiated as industrial hubs can be a crucial step towards that goal. The benefits of hydrogen hubs are becoming more tangible and have the potential to play a significant role in the effort to decarbonize the industrial sector, as such, we suggest the Draft IEPR support such efforts.

Europe has begun significant investment in industrial hydrogen hubs as a pathway to support decarbonization. The United Kingdom (UK) is already starting on an industrial cluster project called Zero Carbon Humber, which will use hydrogen technology and carbon capture to aim for a net-zero industrial cluster in Humber, where the UK's largest industrial cluster resides.<sup>106</sup> The Zero Carbon Humber project involves a 12-company partnership where CO<sub>2</sub> transport and storage infrastructure can be shared, new jobs can be created, and the resulting low-carbon hydrogen can be utilized by major industry, power generation, and other key sectors. Another effort in Europe that encompasses hydrogen industrial clusters is the European Hydrogen Backbone. This is an initiative that has currently grown to 23 European infrastructure companies that are working

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<sup>101</sup> See CEC, Roadmap for the Deployment and Buildout of Renewable Hydrogen Production Plants in California, June 2020, page C-28 Conclusions, available at <https://cafc.org/sites/default/files/Roadmap-for-Deployment-and-Buildout-of-RH2-UCI-CEC-June-2020.pdf>.

<sup>102</sup> See Accenture, Industrial Clusters Working Together to Achieve Net Zero, March 1, 2021, slide 5, [https://www.accenture.com/\\_acnmedia/PDF-147/Accenture-WEF-Industrial-Clusters.pdf#zoom=40](https://www.accenture.com/_acnmedia/PDF-147/Accenture-WEF-Industrial-Clusters.pdf#zoom=40).

<sup>103</sup> See Green Hydrogen Coalition's comment "DOE Hydrogen Program Response to RFI #DE-FOA-0002529," July 7, 2021, page 3, available at Filings — GREEN HYDROGEN COALITION ([ghcoalition.org](http://ghcoalition.org)).

<sup>104</sup> See U.S. DOE, Hydrogen Fueling Station Locations, August 10, 2021, available at [https://afdc.energy.gov/fuels/hydrogen\\_locations.html#/find/nearest?fuel=HY](https://afdc.energy.gov/fuels/hydrogen_locations.html#/find/nearest?fuel=HY).

<sup>105</sup> See Mayor Eric Garcetti "L.A.'s Green New Deal Sustainable City Plan 2019," April 2019, pg. 13, available at [https://plan.lamayor.org/sites/default/files/pLAN\\_2019\\_final.pdf](https://plan.lamayor.org/sites/default/files/pLAN_2019_final.pdf).

<sup>106</sup> See World Economic Forum, "Why Industrial Clusters Can Be the Heart of the Green Revolution," available at <https://www.weforum.org/agenda/2021/03/decarbonizing-industrial-clusters-green-revolution/>.

together to plan a pan-European dedicated hydrogen transport infrastructure to connect various hydrogen industrial clusters throughout Europe.<sup>107</sup>

#### **14. Incentives should advance pilot projects that help bring clean fuels to scale.**

Volume I of the Draft IEPR states that: “The Food Production Investment Program should serve as a model for future funding programs for industry, manufacturing, and agriculture. These programs should invest in both drop-technologies that are known to work and emerging technologies with potential for high energy and GHG benefits.”<sup>108</sup> We suggest the Draft IEPR support policies and incentives focused on developing these types of projects and collaborations to help California’s industrial sectors decarbonize as well as increase reliability and resiliency across the entire economy.

Indeed, fuels such as biogas and synthetic natural gas (syngas) are characterized as “drop-in fuels” which, when processed to meet appropriate gas quality standards, can be used instantly where traditional natural gas is used today.<sup>109</sup> Furthermore, international studies performed on hydrogen blending within pipeline and related infrastructure show that hydrogen can be blended in limited amounts into existing natural gas pipelines.<sup>110</sup> On December 14, 2021, SoCalGas announced its partnership with Bloom Energy and Caltech to generate green hydrogen and then blend it into the university’s existing natural gas infrastructure.<sup>111</sup> Per the California State Budget, The May Revision for 2021-2022 regarding investments to accelerate progress on the State’s clean energy goals include approximately \$912 million (\$905 million General Fund, \$5 million reimbursements, and \$2 million special funds) to help position California as a leader in advancing clean technologies and tackling climate change; specifically, \$110 million is allocated to a general fund for “green hydrogen production to accelerate the transition away from using fossil fuels to produce hydrogen and to displace the use of gas at power plants.”<sup>112</sup>

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<sup>107</sup> See European Hydrogen Backbone Initiative, *Extending the European Hydrogen Backbone*, April 2021, available at <https://gasforclimate2050.eu/wp-content/uploads/2021/04/European-Hydrogen-Backbone-2021-Webinar-slidedeck.pdf>.

<sup>108</sup> See 2021 Draft IEPR Volume I, pg. 59.

<sup>109</sup> See SoCalGas Clean Fuels Report, pg. 9, available at [https://www.socalgas.com/sites/default/files/2021-10/Roles\\_Clean\\_Fuels\\_Full\\_Report.pdf](https://www.socalgas.com/sites/default/files/2021-10/Roles_Clean_Fuels_Full_Report.pdf).

<sup>110</sup> See Gas for Climate: A path to 2050, *Extending the European Hydrogen Backbone: A European Hydrogen Infrastructure Vision Covering 21 Countries*, pg. 11.

<sup>111</sup> See SoCalGas and Bloom Energy Showcase Technology to Power Hydrogen Economy with Gas Blending Project, December 14, 2021, available at <https://finance.yahoo.com/news/socalgas-bloom-energy-showcase-technology-135800498.html?guccounter=1>.

<sup>112</sup> See Full Budget Summary for 2021-2022, State of California, pgs. 130-131, available at <https://www.ebudget.ca.gov/2021-22/pdf/Revised/BudgetSummary/FullBudgetSummary.pdf>.

## Appendix E: Modeling Assumptions & Data Errata

### 15. Funding fuel substitution over gas energy efficiency conflicts with SB 350 and PUC 454.55 and 454.56.

During the CEC IEPR Commissioner Workshop on Electricity and Natural Gas Demand Forecast held December 2, 2021, CEC staff stated that “funding a fuel substitution program could mean not funding a gas energy efficiency program.”<sup>113</sup> This sentiment was again emphasized in the Draft IEPR in the following language, “given the inherent competition between gas EE and fuel substitution, staff will need to consider which combinations of Additional Achievable Energy Efficiency (AAEE)/Additional Achievable Fuel Substitution (AAFS) scenarios are compatible given gas displacement potential and program funding sources. It is possible to proportionately scale down natural gas savings in cases where the total penetration of fuel substitution savings exceeds a specified proportion of the total IEPR demand for a given year and sector.”<sup>114</sup>

This statement in the Draft IEPR appears to conflict with SB 350 which codifies California’s goals to double energy efficiency savings in electricity and gas end uses by 2030 and to study barriers to energy efficiency and clean energy for low-income customers and disadvantaged communities. The statement is also in conflict with California Public Utilities Code sections 454.55 and 454.56, which require that the CPUC, in consultation with the Energy Commission, identify all potentially achievable cost-effective natural gas efficiency savings and establish targets for the gas corporations to achieve.<sup>115</sup> We respectfully suggest the Draft IEPR reconcile these two conflicts.

Similarly, the following statement in the Draft IEPR may be making too broad of a statement to presume all “remaining gas consumption” can be easily replaced with fuel substitution measures: “Additional speculative fuel substitution that exceeds modeling results can be applied to the remaining gas consumption to develop more aggressive AAFS scenarios that achieve policy goals.”<sup>116</sup> We suggest this statement in the Draft IEPR be caveated that more modeling needs to be completed to verify its validity.

During the CEC IEPR Workshop on Energy Demand Analysis held December 16, the CEC presented results of the Consumption and Sales Forecast “Mid-AAEE Mid-AAFS” scenario which showed the effects of lowering California’s gas demand forecast by 12 percent by 2035.<sup>117</sup> This seems to be a reasonable projection of future gas demand. In addition, in the same way the CEC developed AAEE scenarios with the investor-owned utilities, we would like to offer our expertise in collaborating with the CEC in future development of AAFS scenarios.

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<sup>113</sup> See CEC IEPR Commissioner Workshop on Electricity and Natural Gas Demand Forecast, CEC, December 2, 2021, available at <https://www.energy.ca.gov/event/workshop/2021-12/session-1-iepr-commissioner-workshop-electricity-and-natural-gas-demand>.

<sup>114</sup> See 2021 Draft IEPR Volume IV, pg. 31 (emphasis added).

<sup>115</sup> See Public Utilities Code 454.55 & 454.56.

<sup>116</sup> See 2021 Draft IEPR Volume IV, pg. 31.

<sup>117</sup> See CEC IEPR Workshop on Energy Demand Analysis, CEC, available at <https://www.energy.ca.gov/event/workshop/2021-12/iepr-commissioner-workshop-energy-demand-analysis>.

**16. TDV metrics should continue to be developed in the Energy Code, while emphasizing that the assumptions embedded into the analysis should reflect the most current data sets available for the cost of electric and gas supply.**

As expressed by the Time Dependent Valuation (TDV) analyses, the intended benefits of the code changes are highly sensitive to variables relating to the future customer cost for the electric supply and delivery infrastructure compared to the future cost for gas supply and delivery infrastructure. To the extent that the CEC's projections do not accurately reflect future energy system costs, the assumed benefits may not materialize and could adversely impact public welfare, especially relating to housing affordability (and lack thereof). Numerous data points, facts and sensitivity analyses suggest that certain assumptions that were used in the 2022 Building Efficiency Code were either overly optimistic and/or do not reflect the most current data sets - suggesting that cost-effectiveness projections for the cost of electric and gas supply and delivery infrastructure do not reasonably reflect likely outcomes.

As one example, reliance on overly pessimistic forecasts of the retail gas prices and likewise overly optimistic forecasts of retail electricity prices used to calculate the TDV is, in and of itself, a key driver of cost comparisons in one direction. We recommend the CEC refine the forecast of natural gas and electricity rates for the TDV calculation on a forward going process.

**17. The classification of factors that constitute the Benefit-Cost Assessment should be presented with greater transparency.**

The Benefit-Cost Assessment discussion on page 35 of the Appendix notes that Health and Safety Code Section 44273 requires each Clean Transportation Program project be accompanied by a benefit-cost assessment, which the Commission provides can be represented by a ratio of dollars awarded to "expected or potential" GHG emissions benefits. SoCalGas respectfully recommends transparency regarding methods of defining and stratifying what factors comprise "expected or potential benefits" and how benefits and costs break out by energy source technology.

As the Commission points out on page 35 of the 2021 Appendix draft, Health & Safety Code sec. 44272(d) requires that, "[t]he commission shall rank applications for projects proposed for funding awards based on solicitation criteria ... and shall give additional preference to funding those projects with higher benefit-cost scores."<sup>118</sup>

Health & Safety Code 44272(d) therefore requires ranking of projects on an individual basis. In developing such ranking, the Commission must consider various enumerated factors in connection with each project, *e.g.*, whether the project uses existing or proposed fueling infrastructure to maximize the outcome of the project, with preference given to projects with higher benefit-cost scores. Based on such requirements, SoCalGas and the public would expect to see a cost-benefit score for each project. As part of this analysis, and considering the CEC's comfort with making long-term projections regarding GHG emission reductions associated with Clean Transportation Program-funded projects through 2030, we suggest the CEC provide technology-by-technology

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<sup>118</sup> In addition, at sec. 44270.3(a), the code defines the required "benefit-cost assessment" for projects supported by the Alternative and Renewable Fuel and Vehicle Technology Fund as "a project's expected or potential greenhouse gas emissions reduction per dollar awarded by the commission."



cost predictions and benefit-cost effectiveness metrics information for each project subclass and fuel system, information which we understand would be gathered in the process of setting rankings and preferences for projects as required by Health and Safety Code 44272.

Although an aggregate benefits-per-dollar-spent statistic for the Clean Transportation Program may be of some value, considerably more illumination could be offered by detailing such information on a project basis as required by the Health and Safety Code. This information would allow a more complete understanding of benefits on the basis of fuel source. As seen below, Table 9 and Table 10 from the Draft IEPR Appendix [reproduced below as Tables 1 and 2] offer only the most basic funding effectiveness information on an aggregate basis.

**Table 1. 2021 Draft IEPR Table 9**

| <b>Table 9: Kilograms CO<sub>2</sub>e Reduced Through 2030 per Clean Transportation Program Dollar [2021 IEPR Draft Appendix]<sup>119</sup></b> |                               |                     |
|---|-------------------------------|---------------------|
| <b>Cost Basis:</b>  | <b>Analyzed Projects Only</b> | <b>All Projects</b> |
| Expected Benefits + Market Transformation (Low Case)  | 56.3 kg per \$                | 40.8 kg per \$      |
| Expected Benefits + Market Transformation (High Case)   | 107.7 kg per \$               | 78.0 kg per \$      |

**Table 2. 2021 Draft IEPR Table 10.**

| <b>Table 10: Clean Transportation Funding per Metric Ton CO<sub>2</sub>e Reduced Through 2030 [2021 IEPR Draft Appendix]<sup>120</sup></b> |                               |                       |
|--|-------------------------------|-----------------------|
| <b>Cost Basis:</b>   | <b>Analyzed Projects Only</b> | <b>All Projects</b>   |
| Expected Benefits + Market Transformation (Low Case)   | \$17.8 per metric ton         | \$24.5 per metric ton |
| Expected Benefits + Market Transformation (High Case)  | \$9.3 per metric ton          | \$12.8 per metric ton |

It would further the public interest to present more complete data, accompanied by appropriate caveats regarding usage, rather than to omit substantive discussion of benefit-cost merits. For example, in contrast to the brevity of the above cost effectiveness information from the Draft IEPR, the November 2021 NREL Guidance Report prepared for CEC includes examples of apparent opportunities to prepare and present more detailed benefit-cost data.<sup>121</sup> Table 2 and Table ES-4 from that report [reproduced below as Table 3 and 4] offer examples of the kinds of data that could be used to present at least some treatment of the potential benefits and costs associated with individual energy technologies.<sup>122</sup>

<sup>119</sup> See 2021 Draft IEPR, Appendix: Assessing the Benefits and Contributions of the Clean Transportation Program, CEC, December 2021, available at <https://efiling.energy.ca.gov/GetDocument.aspx?tn=240865>.

<sup>120</sup> *Ibid.*

<sup>121</sup> See CEC-600-2021-039, California Energy Commission Consultant Report: Analysis of Benefits Associated with Projects and Technologies Supported by the Clean Transportation Program, prepared by NREL for CEC, November 2021, available at <https://efiling.energy.ca.gov/GetDocument.aspx?tn=240837&DocumentContentId=74672>.

<sup>122</sup> *Ibid.*, at pg. 14 and 7, respectively.

**Table 3: 2021 NREL Guidance Report  
Table 2.**

| <i>Project Class</i> | <i>Project Subclass</i> | <i>\$ (mil.)</i> |
|----------------------|-------------------------|------------------|
| Fuel Production      | Biomethane              | \$65.4           |
| Fuel Production      | Diesel Substitutes      | \$56.8           |
| Fuel Production      | Gasoline Substitutes    | \$23.0           |
| Fueling Infrastr.    | Biodiesel               | \$2.0            |
| Fueling Infrastr.    | E85 Ethanol             | \$3.6            |
| Fueling Infrastr.    | Electric Chargers       | \$260.5          |
| Fueling Infrastr.    | Hydrogen                | \$137.0          |
| Fueling Infrastr.    | Natural & Renewable Gas | \$21.5           |
| Vehicles             | CVRP and HVIP Support   | \$28.5           |
| Vehicles             | Demonstration           | \$119.1          |
| Vehicles             | Light Duty BEVs & PHEVs | \$3.4            |
| Vehicles             | LPG Commercial Trucks   | \$3.1            |
| Vehicles             | NG Commercial Trucks    | \$84.1           |
| <b>Grand Total</b>   |                         | <b>808.2</b>     |

**Table 4: NREL 2021 Guidance Report Table ES-4.**

| <i>Project Class</i> | <i>Project Subclass</i>         | <i>2020</i>   | <i>2025</i>   | <i>2030</i>   |
|----------------------|---------------------------------|---------------|---------------|---------------|
| Fuel Production      | Biomethane                      | 25.54         | 250.77        | 264.43        |
| Fuel Production      | Diesel Substitutes              | 258.75        | 963.98        | 964.04        |
| Fuel Production      | Gasoline Substitutes            | 18.18         | 99.38         | 102.8         |
| Fueling Infrastr.    | Biodiesel                       | 23.97         | 23.97         | 23.97         |
| Fueling Infrastr.    | E85 Ethanol                     | 17.82         | 18.13         | 18.13         |
| Fueling Infrastr.    | Electric Chargers               | 33.28         | 285.24        | 499.0         |
| Fueling Infrastr.    | Hydrogen                        | 21.46         | 166.1         | 237.24        |
| Fueling Infrastr.    | Natural & Renewable Natural Gas | 86.17         | 88.85         | 88.85         |
| Vehicles             | CVRP & HVIP Support             | 18.08         | 13.61         | 6.71          |
| Vehicles             | Demonstration                   | 7.9           | 11.99         | 8.8           |
| Vehicles             | LPG Commercial Trucks           | 0.55          | 0.469         | 0             |
| Vehicles             | Light Duty BEVs & PHEVs         | 0.21          | 0.45          | 0.22          |
| Vehicles             | Manufacturing                   | 169.95        | 587.58        | 723.86        |
| Vehicles             | NG Commercial Trucks            | 4.03          | 3.15          | -0.074        |
| <b>Total</b>         |                                 | <b>686.96</b> | <b>2513.7</b> | <b>2938.1</b> |

In order to ensure a robust and balanced understanding of the underlying calculations and their implications, SoCalGas respectfully requests publication of technology-by-technology data detailing – for each source technology – GHG emissions, expected or potential GHG reductions, dollars spent, and expected or potential GHG emissions reductions per program dollar spent, as well as a detailed elaboration regarding how the Commission compares the GHG reductions afforded by individual technologies with one another.

In addition, the Draft IEPR notes (without a citation) that these benefit-cost calculations are to be “on a cumulative basis, not an annual one.”<sup>125</sup> It will be important to understand what time window will be applied and why the selected time frame is best and most appropriately illustrates and illuminates the totality of the information to be conveyed. Moreover, rather than reporting solely on a cumulative basis, we suggest annual data continue to be provided in parallel for the sake of continuity. For example, Tables 34 and 35 from the adopted 2019 IEPR provide expected annual petroleum fuel reduction and GHG reduction information across 13 different project types.<sup>126</sup> Tables 4 and 5 of the 2021 Draft IEPR provide somewhat continuous reporting of those data.<sup>127</sup> A requirement for a cumulative assessment does not preclude release of apples-to-apples annual data that enables longitudinal analysis to continue.

<sup>123</sup> *Ibid.*, at p. 14.

<sup>124</sup> *Ibid.*, at p. 7.

<sup>125</sup> See 2021 Draft IEPR, Appendix, pg. 35.

<sup>126</sup> Adopted 2019 Integrated Energy Policy Report, CEC, May 6, 2020, “Appendix B: Clean Transportation Program Successes and Benefits,” 19-IEPR-01. See, e.g., “Table 34: Funding Analyzed by NREL by Project Type Through March 2019” at pg. B-16. See also, *ibid.*, “Table 35: Annual Petroleum Fuel and GHG Reductions (Expected Benefits)” at pg. B-19, which predicts 2020 and 2030 petroleum fuel and GHG reductions for comparable project types.

<sup>127</sup> See 2021 Draft IEPR, Appendix. See “Table 4: Clean Transportation Program Funding Analyzed by NREL by Project Type Through August 2021” at pg. 25. See also, *ibid.*, “Table 5: Annual Petroleum Fuel and GHG Reductions (Expected Benefits),” at pg. 28.

To guide its prioritization process, California Health & Safety Code Section 44272(c) and 44272(d) enumerate 12 factors for the Commission to consider in comparing and ranking proposals – including to what extent a project furthers the transition to alternative fuels, is consistent with climate and LCFS policies, reduces criteria pollutants and water pollutants, ensures natural resource sustainability, uses nonstate matching funds, supports technology industries and jobs, uses existing or proposed fueling infrastructure, substantially reduces lifecycle GHG emissions from RFG and diesel standards, uses at least 20+ percent alternative fuel blends, drives technology advancement, and supports job growth for alternative & renewable fuel and vehicle technology sector – and direct that additional preference be given to projects with a high benefit-cost scores. Insofar as the Commission is statutorily required to assess and rank proposed project applications based on an array of criteria, it would serve the public interest to provide a full and detailed explanation of the mechanics by which that entire assessment and ranking process takes place with respect to project applications, as well as to make use of the underlying project-level data regarding both funding level and criteria assessed to enhance public information regarding program costs and benefits.

Since 2014, the IEPR development process has been supported by a guidance document from NREL entitled “Analysis of Benefits Associated with Projects and Technologies Supported by the Clean Transportation Program,”<sup>128</sup> and the 2021 Draft IEPR benefits from a 2021 update to that document.<sup>129</sup> The NREL guidance document offers extensive background regarding the benefits associated with a wide array of technologies and usage scenarios.

In many cases, those potential impacts are extrapolated out to 2030. For example, using various input assumptions and parameters, the authors use modeling to predict future technology-by-technology outcomes for numerous factors, including vehicle miles traveled (VMT), vehicle price reductions, induced vehicle sales, CO<sub>2</sub>e cost reductions, and reductions in petroleum, GHGs, PM 2.5, and NO<sub>x</sub>. The report also makes future predictions regarding jobs and job creation benefits to support disadvantaged communities that look several years out.

Yet, despite the willingness to make assumptions-based predictions regarding future benefits in a granular fashion, the authors appear unwilling to attempt a basic assessment of a technology’s potential costs – a metric that could provide parallel data in order to inform a benefit-cost assessment.

Notwithstanding numerous pages of text and tables devoted to benefits of one technology versus another, in many cases projecting those benefits into the future, the guidance document at page 11 offers only two sentences regarding cost effectiveness:

“As in 2014, the benefit estimation method used is not sufficient to determine the comparative effectiveness of different CTP investment categories. Effectiveness metric assessments are limited by the completeness and consistency of the cost-share information

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<sup>128</sup> See “Analysis of Benefits Associated with Projects and Technologies Supported by the Clean Transportation Program,” prepared by NREL for CEC, November 2021, available at <https://efiling.energy.ca.gov/GetDocument.aspx?tn=73202&DocumentContentId=10111>.

<sup>129</sup> See Consultant Report: Analysis of Benefits Associated with Projects and Technologies Supported by the Clean Transportation Program, prepared by NREL for CEC, CEC-600-2021-039, November 2021, available at <https://efiling.energy.ca.gov/GetDocument.aspx?tn=240837&DocumentContentId=74672>.

provided for each project (or lack thereof) as well as by the uncertainty in future market outcomes and timescales.”<sup>130</sup>

The concern expressed regarding uncertainty in future market outcomes and timescales seems curious given that those concerns could be raised similarly with respect to the benefits assumptions used in the document. Mileage, usage, adoption, savings, and sales are all subject to variability when projected into the future. As such, it would be informative to know why caveating language such as that quoted in the preceding paragraph should be necessary for benefit-cost data but not for the predicted benefits themselves. In furtherance of the public interest, we suggest the Draft IEPR include a technology-by-technology cost prediction and benefit-cost effectiveness metrics for each Clean Transportation Program project type, subclass, and fuel system. We believe the results will show that for every dollar spent by the Clean Transportation Program, more greenhouse gas emissions reductions occur from the renewable fuel production projects and therefore recommend the Energy Commission include these types of projects as it seeks to reauthorize the program in the next legislative cycle.

#### **18. Emission reductions are projected to result from electrification, not from decommissioning of the natural gas delivery infrastructure.**

Decommissioning of natural gas infrastructure does not necessarily bear a causal relationship to reducing emissions, which is sometimes mistakenly presumed to exist. In a previous CEC workshop focused on Strategic Pathways and Analytics for Tactical Decommissioning of Portions of Natural Gas Infrastructure, a hypothesis was presented that “targeted electrification in geographically specific regions could be combined with strategic decommissioning of gas infrastructure in order to reduce total gas system costs and thereby help to mitigate future rate impacts for remaining customers.” It was clearly stated that this hypothesis “hasn't been tested or validated at any scale.”<sup>131</sup> This hypothesis does not express or imply a causal relationship between decommissioning and emission reductions. Rather, it is theorized that decommissioning may provide a means to mitigate disparate and disproportionate rate impacts that are caused by electrification, which is the emissions reductions lever. We suggest the Draft IEPR acknowledge that natural gas pipeline infrastructure decommissioning does not directly bear a formative relationship to reducing emissions. We suggest the results of ongoing pilot studies be evaluated before moving forward with a definitive approach.

#### **19. Underlying assumptions used to develop Additional Achievable Fuel Substitution (AAFS) and Long-Term Demand Scenarios should be presented with greater transparency.**

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<sup>130</sup> *Ibid.*, at pg. 11.

<sup>131</sup> Transcriptions of workshop statements in this comment letter should be considered unofficial and are based on the publicly web-provided workshop video. Zoom recording available at [https://energy.zoom.us/rec/play/q45LKz4kATIr\\_cqamhc8ECvZVoPpidfaUjZV8zXgtiCemB5qabh\\_YHeIyaAW2XaWgi5XxmUmdJKrEBgs.GJ8oyGESRe6AKsSO?startTime=1637172027000&\\_x\\_zm\\_rtaiid=T0ieoV9KTkeWqBn3WE7\\_2w.1638317202212.5e44cb1ccb87f955f7be16a88b308165&\\_x\\_zm\\_rhtaid=149](https://energy.zoom.us/rec/play/q45LKz4kATIr_cqamhc8ECvZVoPpidfaUjZV8zXgtiCemB5qabh_YHeIyaAW2XaWgi5XxmUmdJKrEBgs.GJ8oyGESRe6AKsSO?startTime=1637172027000&_x_zm_rtaiid=T0ieoV9KTkeWqBn3WE7_2w.1638317202212.5e44cb1ccb87f955f7be16a88b308165&_x_zm_rhtaid=149).

The CEC provided minimal detail regarding the electric penetration rate used to develop the Low, Mid, and High cases for its Additional Achievable Fuel Substitution (AAFS) modeling results for the 2021 IEPR. In a follow up meeting with staff, I understand that the AAFS was developed bottom up from potential programs and not via assumptions of percentage of appliance conversions at the end of life. With that said there are still some points of clarification that even if are not explainable now, we would like to work with CEC staff for future forecasts to be able to quantify the policy direction. The following highlight a couple topics that would benefit from clarity:

- It is not clear from the description of the cases provided whether the assumed all electric penetration rates of 0.5 percent, 1.5 percent, and 2.5 percent per year beginning in 2020 used in the Low, Mid, and High cases, respectively, are being used in addition to the percentage of actual all-electric new construction in 2019.
- The Draft IEPR stated the AAFS demand forecast focuses on all electric new construction only. It is not clear if the CEC will develop an equivalent set of demand forecasts for electrifying existing dwellings.

The same issue exists for the long-term demand scenarios for building decarbonization and transportation electrification that were introduced in this year's Draft IEPR.

- The Draft IEPR states that the “building decarbonization demand scenario will be developed out to 2050.”<sup>132</sup> Will the CEC include utility-area AAFS projections up to 2050 as well? SoCalGas believes AAFS projections by IOU service territory would be beneficial for planning purposes.
- SoCalGas requests clarification on the policy assumptions used in the design of the demand scenarios, specifically the Reference and Policy/Compliance Scenarios. The Draft IEPR states “the incremental difference between the reference and policy/compliance scenario is the impact of fully achieving the intended goal of policy/regulation/program.”<sup>133</sup> Does this mean the Reference scenario assumes policy goals are not fully achieved?

We would like to partner with the CEC's forecasting team similar to the process between the CEC and the large electric utilities to help make the gas forecast and implications thereof on the electricity side more robust in the future.

## **20. Lowering the cost-effectiveness threshold for portfolio programs suggests that energy efficiency programs are less effective than expected.**

The Draft IEPR Volume IV includes an overview of Additional Achievable Energy Efficiency (AAEE) forecast improvements, specifically IOU program contributions to the AAEE. The following changes were made: "AAEE impacts for the IOU service territories are based on the

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<sup>132</sup> See 2021 Draft IEPR Volume IV: California Energy Demand Forecast, CEC, December 7, 2021. Available at <https://efiling.energy.ca.gov/GetDocument.aspx?tn=240867>.

<sup>133</sup> See 2021 Draft IEPR Volume IV, pg. 46.

CPUC's [Draft 2021 Energy Efficiency Potential and Goals Study (PG Study)].<sup>134</sup> The main differences between the 2021 proposed goals and the 2019 predecessor are: A decrease in the threshold for cost-effectiveness of specific measures in some scenarios, 0.85 total resource cost (TRC) rather than the 1.0 TRC threshold required for program portfolios."

A decrease in the cost-effectiveness threshold requirement for program portfolios seems to suggest electric energy efficiency appliances and/or programs may not yield the amount of energy savings previously projected at the price points set by the programs. SoCalGas is concerned the decrease in the threshold for cost-effectiveness from 1.0 to 0.85 could raise equity issues, particularly for low-income households for whom building electrification will impose asymmetrical and inequitable cost burdens.<sup>135</sup> In addition, we suggest the reduced cost effectiveness, and therefore increased cost burden, of considered energy efficient programs be captured in the AAEE Savings scenarios. We suggest the Draft IEPR address equity concerns related to the decrease in the cost-effectiveness threshold requirement for program portfolios, specifically among low-income households in California. We also suggest for these changes to be accounted for in the AAEE Savings Scenarios.

## **21. Fuel substitution may not align with 2018 Energy Action Plan loading order.**

Contextualizing the loading order in the demand forecast, the report indicates that the additional achievable fuel substitution is aligned with the loading order.<sup>136</sup> The loading order was last updated in the 2008 Energy Action Plan, which ranks energy efficiency and demand response highest in importance for procurement of new resources.<sup>137</sup> Fuel Substitution was not contemplated during this time and, thus, it seems like an overstatement to indicate that fuel substitution aligns with the loading order. Fuel substitution at the heart replaces one fuel source for another. It does not inherently mean the new fuel source uses less energy. In fact, the new fuel source could use more energy and be less efficient, while emitting more GHG emissions overtime. It may be worthwhile to re-examine the Energy Action Plan through a stakeholder driver process rather than suggest policy preferences today. We suggest the Draft IEPR re-evaluate the alignment of the AAFS with the loading order of the demand forecast and consider greater stakeholder engagement in deciding the prioritization of fuel substitution.

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<sup>134</sup> See 2021 Energy Efficiency Potential and Goals Study - July 22 Update (2021 ACC), Guidehouse for CPUC, July 22, 2021. Available at [https://pda.energydataweb.com/api/downloads/2527/2021%20PG%20Study%20Updated%20Results%20Memo%20\(2021%20ACC\).pdf](https://pda.energydataweb.com/api/downloads/2527/2021%20PG%20Study%20Updated%20Results%20Memo%20(2021%20ACC).pdf).

<sup>135</sup> See Lucas Davis, Catherine Hausman, Who Will Pay for Legacy Utility Costs, Energy Institute at Haas University California Berkeley, June 2021. (Those who are least able to electrify could bear the most burden of building decarbonization, disproportionately impacting low- and middle-income households). Available at <https://haas.berkeley.edu/energy-institute/research/abstracts/wp-317/>.

<sup>136</sup> See 2021 Draft IEPR Volume IV, pg. 31.

<sup>137</sup> See 2008 Energy Action Plan Update, adopted by the CPUC and CEC on February 2008, available at: [https://www.cpuc.ca.gov/-/media/cpuc-website/files/uploadedfiles/cpuc\\_public\\_website/content/utilities\\_and\\_industries/energy\\_-\\_electricity\\_and\\_natural\\_gas/2008-energy-action-plan-update.pdf](https://www.cpuc.ca.gov/-/media/cpuc-website/files/uploadedfiles/cpuc_public_website/content/utilities_and_industries/energy_-_electricity_and_natural_gas/2008-energy-action-plan-update.pdf).

**22. Utilizing historical gas consumption data for future IEPRs may not be the most effective approach to advancing the public interest.**

"To plan for meeting the state's decarbonization goals, additional analyses for the gas forecast are needed to assess the impacts of decreasing pipeline gas usage. Staff is exploring available historical gas data to develop a methodology to forecast monthly demand and peak-day pipeline gas demand for future IEPRs."<sup>138</sup> [emphasis added]

SoCalGas questions whether it is advisable to simply rely on historical gas data to develop a methodology for forecasting monthly demand and peak-day pipeline gas demand. As the role of natural gas is changing in California's energy system, we believe it is prudent for modeling for future monthly demand to account for what SoCalGas deems "clean fuels" which includes RNG, green hydrogen, syngas, and biofuels.<sup>139</sup> These clean fuels will bolster peak reliability and provide the critical resiliency needed for climate-caused extreme weather event adaptation. We suggest the Draft IEPR incorporate the advantages that clean fuels, such as RNG, green hydrogen, syngas, and biofuels will provide to existing methodologies used to forecast demand.

**23. Clarification is needed regarding the 2022 Reliability scenarios and figures.**

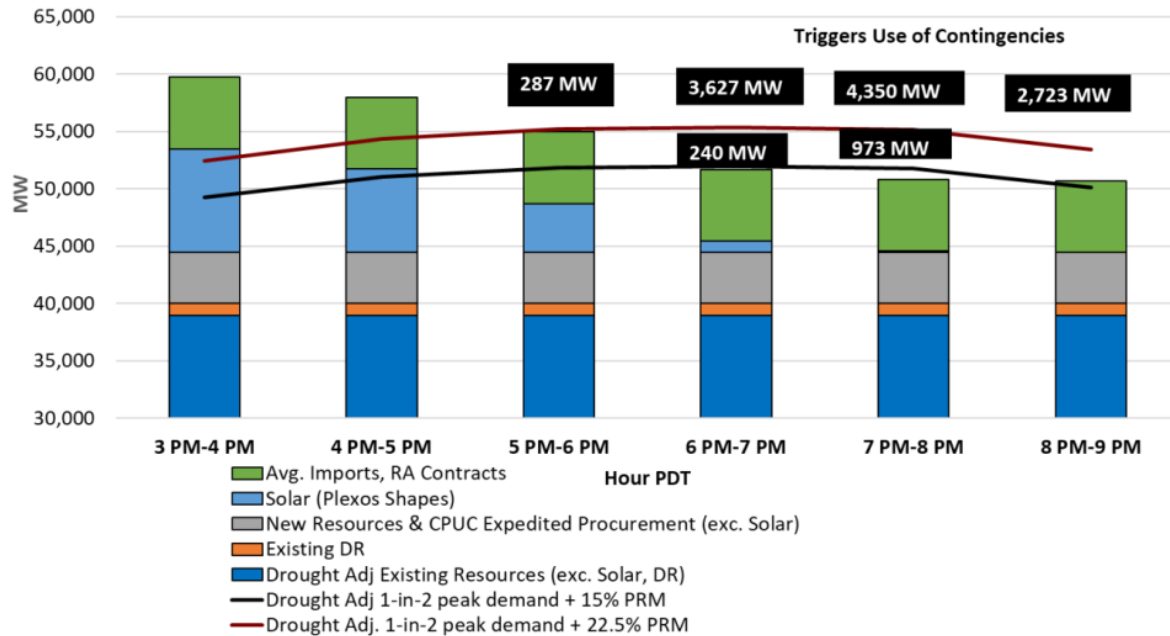
Page 50 of Volume II indicates that a 15 percent and 22.5 percent planning reserve margins are assumed for traditional and extreme weather, respectively. Based on this assumption it further states that under average weather conditions, the resource portfolios are considered adequate to meet demand, but extreme weather may require contingencies. The figure on page 52 [replicated below as Figure 9] looks like there are deficits of 240 MW and 973 MW in September 2022 for the hours between 6-7 pm and 7-8 pm, respectively. Would the CEC clarify whether these gaps indicate a shortfall? If it is a shortfall, we recommend greater detail as to why the resource portfolios are deemed adequate despite the shortfalls of 240 MW and 973 MW.

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<sup>138</sup> See 2021 Draft IEPR Volume IV, pg. 21.

<sup>139</sup> See "SoCalGas Clean Fuels," last modified November 9, 2021, available at <https://www.socalgas.com/sustainability/clean-fuels>.

Figure 9: CEC’s September 2022 Stack Analysis<sup>140</sup>



Source: California Energy Commission. Publication Number: CEC-200-2021-006

## 24. The State’s Decarbonization Strategy tends to be misconstrued and conflated with electrification.

SoCalGas identified the statements below which are overly absolute and binary regarding building decarbonization and the future role of the gas system. We suggest the Draft IEPR avoid overly binary language regarding building decarbonization and the future role of the gas system and incorporate suggested edits to provide the public with a more balanced and accurate report.

We suggest edits as shown in red below. These are:

- "To reach this goal [of California reducing GHG emissions by 80% below 1990 levels by 2050], residential and commercial buildings will electrify where achievable and cost effective, and so the state must plan for reducing optimizing gas use on the state’s gas system."
- "A decarbonization strategy of replacing gas end uses with cleaner and more efficient electric end uses where achievable and cost effective has significant implications for the electricity and gas forecasts."

<sup>140</sup> See “CEC Staff Paper, 2022 Summer Stack Analysis,” CEC, September 2021, pg. 13, available at file:///C:/Users/jlu/Downloads/TN239635\_20210908T135116\_Staff%20Paper%20-%20Revised%202022%20Summer%20Supply%20Stack%20Analysis.pdf.



## 25. Imports data and characterization revisions are needed.

Page 36 of Volume II indicates that 21 percent of CAISO’s supply comes from imports, the majority of which is from the Pacific Northwest.<sup>141</sup> However, according to the CEC’s Total System Power Report, imports are much higher and represent around 30 percent of total imports as seen below in Table 5.<sup>142</sup> Further, in 2020, imports were split between the Northwest and Southwest with 41,193 GWh and 40,471 GWh, respectively.<sup>143</sup>

**Table 5: CAISO Imports from 2016 to 2020**

| <b>Year</b>       | <b>2016</b> | <b>2017</b> | <b>2018</b> | <b>2019</b> | <b>2020</b> |
|-------------------|-------------|-------------|-------------|-------------|-------------|
| Imports (MW)      | 92,326      | 85,704      | 90,648      | 77,229      | 81,663      |
| Total Supply (MW) | 290,792     | 292,083     | 285,656     | 277,933     | 272,576     |
| Percent Imports   | 32%         | 29%         | 32%         | 28%         | 30%         |

Page 2 of Volume II states “on average, the state may need to build up to 6 gigawatts (GW) of new renewable and storage resources annually. By comparison, over the last decade, the state has built on average 1 GW of utility solar and 300 MW of wind per year.”<sup>144</sup> Since comparisons are drawn to wind and solar construction trends, it would be helpful to also include battery storage trends.

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<sup>141</sup> See 2021 Draft IEPR, Volume II, pg. 36.

<sup>142</sup> Based on data in the 2020 Total System Power Report that shows imports versus total supply for the past five years. See 2020 Total System Electric Generation, Michael Nyberg, webpage available at <https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2020-total-system-electric-generation>.

<sup>143</sup> *Ibid.*

<sup>144</sup> See 2021 Draft IEPR, Volume II, pg. 2.

**Attachment 1: Ramboll Memorandum Regarding Comparison of Lifetime Emissions and Cost-Effectiveness of Class 8 Heavy-Duty Truck Technologies**

# MEMORANDUM

To: Kevin Barker  
Southern California Gas Company

From: Akshay Ashok, Varalakshmi Jayaram, and Julia Lester  
Ramboll US Consulting, Inc.

Subject: **COMPARISON OF LIFETIME EMISSIONS AND  
COST-EFFECTIVENESS OF CLASS 8  
HEAVY-DUTY TRUCK TECHNOLOGIES**

## INTRODUCTION

December 16, 2021

A key aspect of the California Air Resources Board's (CARB's) strategy to reducing the impact of short-lived climate pollutants (SLCPs), such as methane, in California is to capture fugitive methane emissions from landfills and dairy manure. In the 2022 Scoping Plan Update meeting on September 8<sup>th</sup>, 2021, CARB staff noted that 45% of methane emissions in California today are fugitive emissions from landfills and dairy manure. CARB staff propose to capture methane emissions from these processes and direct it towards end uses such as transportation, electricity generation, and industrial heating.<sup>1</sup>

Renewable natural gas (RNG) is widely used as a transportation fuel for medium- and heavy-duty trucks in California. In 2020, RNG consumption reduced greenhouse gas (GHG) emissions by 3.5 million metric tons (MMT) of carbon dioxide (CO<sub>2</sub>) equivalent. This is similar to taking 760,000 passenger vehicles off the road or avoiding approximately 394 million gallons of gasoline consumed.<sup>2</sup> By the first quarter of 2021 98% of the natural gas (NG) used in California's transportation sector was RNG,<sup>3</sup> and CARB projects that by 2022 this proportion will reach 100%.<sup>4</sup> CARB's Low Carbon Fuel Standard (LCFS) program has already certified numerous viable pathways for the conversion of fugitive methane emissions from landfill gas

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<sup>1</sup> As noted in California Air Resources Board's (CARB's) presentation during the September 8th Public Workshop on the Scoping Plan Update. Presentation slides available at: [https://ww2.arb.ca.gov/sites/default/files/2021-09/carb\\_presentation\\_sp\\_slcp\\_september2021\\_0.pdf](https://ww2.arb.ca.gov/sites/default/files/2021-09/carb_presentation_sp_slcp_september2021_0.pdf). Accessed: December 2021.

<sup>2</sup> "Decarbonize Transportation with Renewable Natural Gas," RNG Coalition and NGV America, April 2021. Available at <https://ngvamerica.org/wp-content/uploads/2021/04/Decarbonize-Transportation-with-RNG-Updated-April-16-2021.pdf>. Accessed: December 2021.

<sup>3</sup> Available at: [https://ww2.arb.ca.gov/sites/default/files/2021-09/rngcoalition\\_presentation\\_sp\\_slcp\\_september2021\\_0.pdf](https://ww2.arb.ca.gov/sites/default/files/2021-09/rngcoalition_presentation_sp_slcp_september2021_0.pdf). Accessed: December 2021.

<sup>4</sup> Available at: [https://ww2.arb.ca.gov/sites/default/files/2021-09/Proposed\\_2020\\_Mobile\\_Source\\_Strategy.pdf](https://ww2.arb.ca.gov/sites/default/files/2021-09/Proposed_2020_Mobile_Source_Strategy.pdf). Accessed: December 2021.

and animal waste into RNG,<sup>5</sup> thereby creating a viable market for fugitive methane emissions captured from landfill gas and animal waste at a large scale. Finally, NG vehicle technology has already proven to be commercially viable and there exists considerable distribution and fueling infrastructure for dispensing NG or RNG.<sup>6</sup> A March 2021 multi-technology pathway study conducted by Ramboll<sup>7</sup> evaluated lifecycle greenhouse emissions for heavy heavy-duty trucks (HHDTs) and determined that Optional Low-NO<sub>x</sub> RNG trucks are able to achieve GHG reductions more cost-effectively than a battery-electric HHDT (NO<sub>x</sub> is oxides of nitrogen, a criteria pollutant and key precursor to ozone and particulate matter pollution).

Despite this, CARB's Proposed 2020 Mobile Source Strategy and associated regulatory actions have all been aimed at widespread vehicle electrification of California's on-road HHDT fleet, with little consideration for the role of RNG-fueled vehicle technologies. This is clearly seen by the recent strategies and rulemaking proposals released by CARB such as the Proposed 2020 Mobile Source Strategy (MSS),<sup>8</sup> the Advanced Clean Trucks (ACT) Regulation,<sup>9</sup> and the proposed Advanced Clean Fleet (ACF) Regulation.<sup>10</sup> For example, the ACT regulation requires manufacturers to sell zero-emission trucks at an increasing rate from 2024 to 2035. Under the proposed ACF rule, high priority private and federal fleets, public fleets, and drayage fleets will be required to transition their fleets to zero emission vehicles (ZEVs) beginning in 2025. The proposed ACF rule also includes a 100% ZEV sales mandate on all medium- and heavy-duty vehicles that would begin in 2040.<sup>11</sup> CARB's ZEV-centric approach, particularly for the HHDT sector, will not have significant benefits in the near-term (5-10 years).<sup>12</sup> Further, CARB's actions preclude potential reductions in GHG emissions (including those from SLCPs) resulting from increased RNG production from captured landfill and animal waste biogas which would be required to meet growing demand for RNG fuels if CARB promotes increased use of Optional Low-NO<sub>x</sub> RNG vehicles.

This memorandum describes the results of a comparative evaluation of the lifetime emissions and cost-effectiveness of emissions reductions for both an Optional Low-NO<sub>x</sub> RNG and a Battery Electric (BE) Class 8 HHDT, compared to a diesel Class 8 HHDT. This analysis quantifies the well-to-wheel GHG emissions and tailpipe SLCP emissions for a Model Year 2024 Class 8 HHDT. Tailpipe NO<sub>x</sub> emissions

<sup>5</sup> Available at: <https://ww2.arb.ca.gov/our-work/programs/low-carbon-fuel-standard>. Accessed: December 2021.

<sup>6</sup> A large existing network of NG fueling stations has been available for over 5 years ([https://ww2.energy.ca.gov/almanac/transportation\\_data/cng-lng.html](https://ww2.energy.ca.gov/almanac/transportation_data/cng-lng.html)) and is still growing. For example, NG fueling stations are available at multiple locations across California (<https://cngvc.org/news/fueling-stations/>), with almost 200 public-access sites.

<sup>7</sup> Available at: <https://www.wspa.org/wp-content/uploads/Multi-technology-Truck-Emission-Reduction-Scenarios-White-Paper-FINAL.pdf>. Accessed: December 2021.

<sup>8</sup> 2021. Proposed 2020 Mobile Source Strategy. September 28. Available at: [https://ww2.arb.ca.gov/sites/default/files/2021-09/Proposed\\_2020\\_Mobile\\_Source\\_Strategy.pdf](https://ww2.arb.ca.gov/sites/default/files/2021-09/Proposed_2020_Mobile_Source_Strategy.pdf). Accessed: December 2021.

<sup>9</sup> CARB. Advanced Clean Trucks. Available at: <https://ww2.arb.ca.gov/our-work/programs/advanced-clean-trucks>. Accessed: December 2021.

<sup>10</sup> CARB. Advanced Clean Fleets. Available at: <https://ww2.arb.ca.gov/our-work/programs/advanced-clean-fleets>. Accessed: December 2021.

<sup>11</sup> ACF proposed rule language, public workshop presentations, and submitted stakeholder comments are available on the CARB ACF website. Available at: <https://ww2.arb.ca.gov/our-work/programs/advanced-clean-fleets/advanced-clean-fleets-meetings-events>. Accessed: December 2021.

<sup>12</sup> As noted by stakeholders in the CARB workshops and public meetings for these regulations, ZEV technology is not commercially available to meet the needs of all duty cycles of Class 8 HHDTs today. This is further reiterated in South Coast Air Quality Management District's (SCAQMD's) letter to Partners in Environmental Justice and Environmental Health dated August 3, 2021, where SCAQMD states "there are substantial challenges regarding whether the duty cycles for ZE Class 8 vehicles can meet business needs, and whether a service network is available for businesses that acquire these vehicles." SCAQMD letter is available at: <https://pantheonstorage.blob.core.windows.net/environment/Draft-Revised-Maritime-Clean-Air-Strategy-Comment-Letters-8-5-to-9-3-21.pdf>. Pages 20-28. Accessed: December 2021.

were also evaluated due to their relevance for the ozone attainment plan for the South Coast Air Basin (SCAB). A key goal of the analysis is to compare the potential emission reductions when a fleet of diesel HHDTs is replaced with comparable Optional Low-NO<sub>x</sub> RNG trucks compared to comparable BE trucks, for the same level of vehicle purchase investment. The following sections present our methodology, discuss results of the study and state important conclusions and considerations of this work.

## METHODOLOGY

The methodology and assumptions used in this study are described below.

- **Vehicle Technologies Assessed:** The study focuses on comparing a conventional Diesel, Optional Low-NO<sub>x</sub> RNG and a BE Model Year 2024 Class 8 HHDT.
- **Vehicle Activity Assumptions:** Ramboll used a 10-year vehicle lifespan and a lifetime mileage of 43,500 miles per year based on the US EPA definition of HHDT useful life,<sup>13</sup> and consistent with CARB's Low-NO<sub>x</sub> Omnibus Regulation.<sup>14</sup> Lifetime mileage was equally distributed across each operating year. All three vehicle technologies were evaluated assuming the same lifespan and lifetime mileage.
- **Pollutants Assessed:** This study evaluates running exhaust emissions of GHGs, SLCPs, and ozone precursors from each truck type. SLCPs evaluated include methane (CH<sub>4</sub>) and black carbon (BC), while GHGs include SLCPs as well as carbon dioxide (CO<sub>2</sub>) and nitrous oxide (N<sub>2</sub>O). Tailpipe NO<sub>x</sub> emissions were evaluated as an ozone precursor pollutant. Additionally, the study evaluates GHG emissions from upstream processing of diesel, RNG and electricity. GHG emissions are presented in metric tons of CO<sub>2</sub>-equivalents (CO<sub>2</sub>e) using 100-year GWP values of 25, 1, and 298 for CH<sub>4</sub>, CO<sub>2</sub>, and N<sub>2</sub>O respectively<sup>15</sup> from the International Panel on Climate Change's (IPCC's) Fourth Assessment Report (AR4) which is consistent with CARB's GHG inventory calculations at the time of this study.<sup>16</sup> Ramboll also used a 100-year GWP of 900 for BC based on CARB's 2015 Black Carbon Emissions Inventory.<sup>17</sup>
- **Tailpipe Emissions:** Ramboll used the most current version of CARB's on-road mobile source emission inventory EMFAC2021<sup>18</sup> to estimate the tailpipe emission rates of pollutants. The EMFAC202x category of T7 Tractor Class 8 was used to model a Class 8 HHDT, and the model year was set to 2024 (the year that CARB's ACT and proposed ACF regulations begin). Tailpipe emission rates (grams/mile) are calculated for each calendar year by taking total emissions in grams and dividing by the corresponding VMT. These emission factors are presented in **Tables 1 and 2**. Vehicle fuel efficiency<sup>19</sup> (for diesel and RNG vehicles) and energy efficiency (for BE trucks) was also

<sup>13</sup> Available at: <https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-86/subpart-A/section-86.004-2>. Accessed: December 2021.

<sup>14</sup> A period called the regulatory useful life is currently 10 years and 435,000 miles for the heaviest diesel engine per CARB Board Resolution 20-23 dated August 27, 2020. Available at: <https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2020/hdomnibuslownox/res20-23.pdf>. Accessed: December 2021.

<sup>15</sup> Available at: [https://archive.ipcc.ch/publications\\_and\\_data/ar4/wg1/en/ch2s2-10-2.html](https://archive.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html). Accessed: December 2021.

<sup>16</sup> Available at: <https://ww2.arb.ca.gov/ghg-inventory-data>. Accessed: December 2021.

<sup>17</sup> Available at: [https://ww3.arb.ca.gov/cc/inventory/slcp/doc/bc\\_inventory\\_tsd\\_20160411.pdf](https://ww3.arb.ca.gov/cc/inventory/slcp/doc/bc_inventory_tsd_20160411.pdf). Accessed: December 2021.

<sup>18</sup> Available at: <https://arb.ca.gov/emfac/emissions-inventory/>. Accessed: December 2021.

<sup>19</sup> Vehicle fuel efficiency is reported in mi/DGE (miles per diesel gallon equivalent). It is assumed that the EMFAC fuel consumption data for natural gas trucks is reported in units of diesel gallon equivalents, per Figure 5.3-7 in the EMFAC 2021 Volume III Technical Document. Available at: [https://ww2.arb.ca.gov/sites/default/files/2021-03/emfac2021\\_volume\\_3\\_technical\\_document.pdf](https://ww2.arb.ca.gov/sites/default/files/2021-03/emfac2021_volume_3_technical_document.pdf). Accessed: December 2021.

calculated, as presented in **Tables 3, 4, and 5**. Input parameters for the EMFAC2021 model run are shown below:

- Run Mode: Emissions
  - Region: Statewide
  - Calendar Years: 2024-2033
  - Season: Annual
  - Vehicle Category: EMFAC202x – T7 Tractor Class 8
  - Model Year: 2024
  - Fuel: By Fuel
  - Speed: Aggregated
  - Pollutants: CH<sub>4</sub>, CO<sub>2</sub>, N<sub>2</sub>O, PM<sub>2.5</sub>, NO<sub>x</sub>
- **Tailpipe Black Carbon Emissions**: Since EMFAC calculates exhaust particulate matter that is 2.5 microns or less in diameter PM<sub>2.5</sub> emissions but does not calculate BC emissions, Ramboll calculated BC emissions based on PM<sub>2.5</sub> emissions and particulate matter speciation factors provided in CARB’s 2015 Black Carbon Emissions Inventory.<sup>20</sup> A factor of 0.264363 was used for diesel trucks following the “Diesel Vehicle Exhaust” profile, while a factor of 0.2 was used for the Optional Low-NO<sub>x</sub> RNG truck based on the “Stationary I.C. Engine – Gas” profile.
  - **Upstream Emission Factors**: Upstream emission factors for diesel and electricity were estimated using the CA-GREET 3.0 model.<sup>21</sup> The model defaults for electric grid mix and transportation distances were adjusted to reflect future California grid projections (assuming the electricity grid continues to decarbonize), as described in Ramboll’s multi-technology pathway study.<sup>22</sup> Upstream emissions for Optional Low-NO<sub>x</sub> RNG trucks were estimated using average certified pathway carbon intensities (CIs) for RNG from landfill gas, food wastes, animal waste/dairy digester gas under the California LCFS program,<sup>23</sup> weighted by sales volumes of these fuel pathways from 2019-2020.<sup>24</sup> Calculations for these upstream emission factors are presented in **Table 6**.
  - **Vehicle Total Cost of Ownership (TCO)**: Vehicle TCO was previously calculated for a diesel, Optional Low-NO<sub>x</sub> and BE truck in Ramboll’s multi-technology pathway study.<sup>25</sup> We have used the TCO results corresponding to a 10-year, 435,000 mileage lifetime for each vehicle. For BE trucks, we increased the purchase cost and charging infrastructure for a BE truck by 40%. This is based on a study done by the National Centre for Sustainable Transportation<sup>26</sup> which found that a 40% larger

<sup>20</sup> Available at: [https://ww3.arb.ca.gov/cc/inventory/sicp/doc/bc\\_inventory\\_tsd\\_20160411.pdf](https://ww3.arb.ca.gov/cc/inventory/sicp/doc/bc_inventory_tsd_20160411.pdf). Accessed: December 2021.

<sup>21</sup> Available at: <https://www.arb.ca.gov/fuels/lcfs/ca-greet/ca-greet30-corrected.xlsm>. Accessed: December 2021.

<sup>22</sup> Available at: <https://www.wspa.org/wp-content/uploads/Multi-technology-Truck-Emission-Reduction-Scenarios-White-Paper-FINAL.pdf>. Accessed: December 2021.

<sup>23</sup> Available at: [https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/fuelpathways/current-pathways\\_all.xlsx](https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/fuelpathways/current-pathways_all.xlsx). Accessed: December 2021.

<sup>24</sup> Available at: [https://ww3.arb.ca.gov/fuels/lcfs/dashboard/quarterlysummary/20210730\\_q1datasummary.pdf](https://ww3.arb.ca.gov/fuels/lcfs/dashboard/quarterlysummary/20210730_q1datasummary.pdf). Accessed: December 2021.

<sup>25</sup> Available at: <https://www.wspa.org/wp-content/uploads/Multi-technology-Truck-Emission-Reduction-Scenarios-White-Paper-FINAL.pdf>. Accessed: December 2021.

<sup>26</sup> Genevieve Giuliano, et al., Developing Markets for Zero Emission Vehicles in Short Haul Goods Movement: A Research Report from the National Center for Sustainable Transportation, November 2020. Available at: <https://escholarship.org/uc/item/0nw4q530>. Accessed: December 2021.

fleet of BE trucks would be required to replace a fleet of diesel trucks in 2025, due to weight and range limitations of BE technology.

## RESULTS

Ramboll’s analysis shows that a Class 8 HHD Optional Low-NO<sub>x</sub> RNG truck can generate greater reductions in lifecycle (well-to-wheel) GHG emissions than a BE truck when replacing a conventional diesel truck. **Tables 1-5** show tailpipe and upstream emissions for each vehicle technology and year. As indicated in **Table 7**, a Model Year (MY) 2024 Optional Low-NO<sub>x</sub> RNG HHDT can reduce lifecycle GHG emissions by approximately 760 metric tons of carbon dioxide equivalent (MT CO<sub>2</sub>e) over its ten-year lifetime as compared to its diesel counterpart. These GHG reductions are 70 MT CO<sub>2</sub>e greater than the reductions that can be achieved by replacing the diesel truck with a BE truck. Note that tailpipe CO<sub>2</sub> emissions from the Optional Low-NO<sub>x</sub> RNG is eliminated due to the biogenically-based nature of these fuels.<sup>27,28</sup> Specifically, the carbon in the biomass used to produce RNG (e.g., feedstocks such as animal/food wastes or biogas from landfills) is part of the terrestrial carbon cycle, where CO<sub>2</sub> resulting from the combustion of biogenically-derived fuels simply returns to the atmosphere carbon that was absorbed by biogenic material (plants) as they were growing.<sup>29</sup>

From a cost perspective, as noted in **Table 8** the total cost of ownership of an Optional Low-NO<sub>x</sub> RNG truck is approximately ~14% lower than a diesel truck<sup>30</sup> and ~53% lower than a BE truck.<sup>31</sup> Since both the TCO and GHG emissions over the lifetime of an Optional Low-NO<sub>x</sub> RNG truck are lower than those for a diesel truck, the cost-effectiveness for replacing a diesel truck with an Optional Low-NO<sub>x</sub> RNG truck is below zero. Thus, as compared to an equivalent fleet of BE trucks, Optional Low-NO<sub>x</sub> RNG trucks provide more cost-effective GHG emission reductions when replacing a diesel truck. Note, the cost estimates for the BE Truck do not account for the additional dollars that have to be spent to upgrade the electric grid to support a zero emission transition in the transportation sector. For example, the California Energy Commission (CEC) funded 2018 E3 Study, Deep Decarbonization in a High Renewables Future,<sup>32</sup> estimates that cumulative costs for the grid infrastructure maintenance and upgrades for a High Electrification Scenario would be \$1.82 trillion between 2020 to 2050.<sup>33</sup>

Ramboll also conducted an assessment of the potential reductions in tailpipe NO<sub>x</sub> emissions from replacing diesel trucks with Optional Low-NO<sub>x</sub> RNG and BE ones. As shown in **Table 9** Optional Low-NO<sub>x</sub> RNG trucks can achieve almost the same reductions in tailpipe NO<sub>x</sub> emissions as a BE truck when used to replace a Class 8 HHD diesel truck. As noted previously, since these Optional Low-NO<sub>x</sub> RNG trucks are

<sup>27</sup> This approach is consistent with US EPA, who state that “tailpipe emissions of CO<sub>2</sub> from RNG fuels are considered carbon neutral because the carbon is biogenic, while tailpipe emissions of CO<sub>2</sub> from fossil natural gas fuels are not.” Available at: [https://www.epa.gov/sites/default/files/2020-07/documents/lmop\\_rng\\_document.pdf](https://www.epa.gov/sites/default/files/2020-07/documents/lmop_rng_document.pdf). Accessed: December 2021.

<sup>28</sup> This approach is also consistent with CARB’s treatment of tailpipe CO<sub>2</sub> emissions in its LCFS Tier 1 Calculator for Biomethane from North American Landfills. Available online at: <https://www.arb.ca.gov/fuels/lcfs/ca-greet/tier1-lfg-calculator.xlsm>. Accessed: December 2021.

<sup>29</sup> Available at: <https://www.ieabioenergy.com/iea-publications/faq/woodybiomass/biogenic-co2/>. Accessed: December 2021.

<sup>30</sup> As noted in Table B-15 in Appendix B of Ramboll’s multi-technology pathway study, the reductions in TCO for an Optional Low NO<sub>x</sub> natural gas truck as compared to its diesel counterpart is driven by the improved fuel economy and lower fuel costs (natural gas compared to diesel) which in turn to lower lifetime fuel costs.

<sup>31</sup> This total cost of ownership includes a replacement ratio adjustment of 1.4 for the purchase and charging infrastructure costs for Battery Electric trucks.

<sup>32</sup> Available at: [https://www.ethree.com/wp-content/uploads/2018/06/Deep\\_Decarbonization\\_in\\_a\\_High\\_Renewables\\_Future\\_CEC-500-2018-012.pdf](https://www.ethree.com/wp-content/uploads/2018/06/Deep_Decarbonization_in_a_High_Renewables_Future_CEC-500-2018-012.pdf). Accessed: December 2021.

<sup>33</sup> The study is available at: [https://www.ethree.com/wp-content/uploads/2017/02/California\\_PATHWAYS\\_Technical\\_Appendix\\_20150720.pdf](https://www.ethree.com/wp-content/uploads/2017/02/California_PATHWAYS_Technical_Appendix_20150720.pdf). Accessed: December 2021.

commercially available today, transitioning to them can result in near-term NO<sub>x</sub> reductions needed in the South Coast Air Basin and San Joaquin Valley Air Basin to achieve the upcoming federal Clean Air Act (CAA) ozone and PM<sub>2.5</sub> attainment deadlines in 2023, 2024, 2025 and 2031.

Finally, we compared the lifetime emission reductions that could result from a given amount of investment into Optional Low-NO<sub>x</sub> RNG or BE trucks, when used to replace diesel trucks. As noted during the SCAQMD Board Retreat on September 16 and 17, 2021, CARB's proposed funding for a multi-year ZEV package begins with an initial installment of \$3.9 billion for the first three budget years,<sup>34</sup> which is a little over a one-billion-dollar investment per year. **Table 10** presents an evaluation of the potential GHG and NO<sub>x</sub> emission reductions that could be achieved with an investment of \$1 Billion in MY2024 Optional Low-NO<sub>x</sub> RNG trucks compared to the same investment in MY2024 BE trucks. Because a BE truck cannot haul the same amount of goods as a diesel truck due to weight and range limitations, the calculations assume that a single BE truck replaces only approximately 0.7 diesel trucks. This contrasts with Optional Low-NO<sub>x</sub> RNG trucks that can replace diesel trucks on a one-to-one basis. **An investment of a billion dollars in Optional Low-NO<sub>x</sub> RNG trucks in 2024 would generate 3.1 times more black carbon reductions, 2.8 times more lifecycle GHG reductions, and 2.9 times more tailpipe NO<sub>x</sub> reductions (needed to meet Clean Air Act Requirements) in comparison to the equivalent investment in BE trucks.** This still does not account for the cost and implementation time of expanded electricity generation, transmission, and distribution. Even greater reductions can be achieved if the investment was made for incremental costs only.

## CONCLUSION

While recent strategies released by CARB focus on transitioning to a 100% ZEV fleet, Ramboll's analysis has shown that **transitioning to Optional Low-NO<sub>x</sub> RNG trucks today can reduce GHG emissions more quickly and cost-effectively as compared to BE trucks (which should be seen as long-term solutions for many duty-cycles)**, while also improving local air quality more quickly per dollar invested. For a given investment in new vehicle technology, **Optional Low-NO<sub>x</sub> RNG trucks could generate approximately 3 times greater emission reductions than an equivalent investment in BE trucks.** Promoting the use of RNG fuel for transportation would facilitate significant reductions in fugitive methane emissions from landfills and dairy manure. Furthermore, starting today, **switching to Optional Low-NO<sub>x</sub> RNG HHD trucks is a cheaper, faster, and surer way** to obtain appreciable greenhouse gas emissions reductions over the next decade compared to the slower replacement with BE trucks.

It should be noted that the estimates provided here with reference to cost effectiveness of emissions reductions are conservative. The TCO estimates for BE trucks do not include the cost needed to expand electricity generation, transmission, and distribution. Additionally, the upstream emissions for RNG fuels in this analysis are calculated based on current carbon intensities which are expected to decrease over time due to a cleaner electric grid. Accounting for these changes would likely further increase the cost effectiveness of Low-NO<sub>x</sub> RNG trucks relative to BE trucks.

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<sup>34</sup> SCAQMD Board Retreat Agenda Package. September 16 and 17, 2021. Available at: <http://www.aqmd.gov/docs/default-source/Agendas/Governing-Board/2021/special-mtg---board-retreat-agenda-package-sept-16-17-2021.pdf?sfvrsn=12>. Accessed: December 2021.



**TABLES**

**Table 1. Diesel Truck Tailpipe Emissions**Southern California Gas Company  
Los Angeles, California

| Calendar Year | EMFAC Output <sup>1</sup> |                     |                       |                     |                     |                     | Tailpipe Emission Factors (g/mile) <sup>1</sup> |         |                 |                 |                  |
|---------------|---------------------------|---------------------|-----------------------|---------------------|---------------------|---------------------|---|---------|-----------------|-----------------|------------------|
|               | Total VMT (mile/day)      | NOx_TOTEX (ton/day) | PM2.5_TOTEX (ton/day) | CO2_TOTEX (ton/day) | CH4_TOTEX (ton/day) | N2O_TOTEX (ton/day) | NO <sub>x</sub>                                 | BC      | CO <sub>2</sub> | CH <sub>4</sub> | N <sub>2</sub> O |
| 2024          | 264,572                   | 0.541               | 0.004                 | 413                 | 0.00058             | 0.06507             | 1.85  | 0.00330 | 1,416           | 0.00200         | 0.223            |
| 2025          | 355,927                   | 0.801               | 0.005                 | 557                 | 0.00083             | 0.08769             | 2.04  | 0.00369 | 1,419           | 0.00211         | 0.224            |
| 2026          | 363,323                   | 0.878               | 0.006                 | 568                 | 0.00089             | 0.08944             | 2.19  | 0.00406 | 1,417           | 0.00223         | 0.223            |
| 2027          | 410,082                   | 1.05                | 0.008                 | 639                 | 0.00106             | 0.10071             | 2.33  | 0.00444 | 1,414           | 0.00234         | 0.223            |
| 2028          | 462,680                   | 1.25                | 0.009                 | 719                 | 0.00125             | 0.11327             | 2.45  | 0.00478 | 1,410           | 0.00245         | 0.222            |
| 2029          | 475,379                   | 1.34                | 0.010                 | 737                 | 0.00134             | 0.11606             | 2.56  | 0.00510 | 1,406           | 0.00256         | 0.221            |
| 2030          | 486,859                   | 1.43                | 0.011                 | 753                 | 0.00143             | 0.11870             | 2.66  | 0.00540 | 1,404           | 0.00266         | 0.221            |
| 2031          | 481,566                   | 1.46                | 0.011                 | 746                 | 0.00146             | 0.11748             | 2.75  | 0.00567 | 1,405           | 0.00276         | 0.221            |
| 2032          | 476,469                   | 1.49                | 0.012                 | 740                 | 0.00150             | 0.11652             | 2.83  | 0.00591 | 1,408           | 0.00285         | 0.222            |
| 2033          | 466,510                   | 1.50                | 0.012                 | 726                 | 0.00151             | 0.11438             | 2.91  | 0.00614 | 1,412           | 0.00294         | 0.222            |



**Table 2. Optional Low-NO<sub>x</sub> RNG Natural Gas Truck Tailpipe Emissions**

Southern California Gas Company  
 Los Angeles, California

| Calendar Year | EMFAC Output <sup>1</sup> |                                  |                       |                                  |                                  |                                  | Tailpipe Emission Factors (g/mile) |         |                 |                 |                  |
|---------------|---------------------------|----------------------------------|-----------------------|----------------------------------|----------------------------------|----------------------------------|------------------------------------|---------|-----------------|-----------------|------------------|
|               | Total VMT (mile/day)      | NO <sub>x</sub> _TOTEX (ton/day) | PM2.5_TOTEX (ton/day) | CO <sub>2</sub> _TOTEX (ton/day) | CH <sub>4</sub> _TOTEX (ton/day) | N <sub>2</sub> O_TOTEX (ton/day) | NO <sub>x</sub>                    | BC      | CO <sub>2</sub> | CH <sub>4</sub> | N <sub>2</sub> O |
| 2024          | 7,044                     | 0.00290                          | 0.0000213             | 9.47                             | 0.0116                           | 0.00193                          | 0.373                              | 0.00055 | 1,220           | 1.49            | 0.249            |
| 2025          | 9,452                     | 0.00402                          | 0.0000291             | 12.8                             | 0.0158                           | 0.00261                          | 0.386                              | 0.00056 | 1,230           | 1.52            | 0.251            |
| 2026          | 9,638                     | 0.00424                          | 0.0000302             | 13.2                             | 0.0165                           | 0.00269                          | 0.399                              | 0.00057 | 1,240           | 1.55            | 0.253            |
| 2027          | 10,867                    | 0.00494                          | 0.0000347             | 15.0                             | 0.0189                           | 0.00305                          | 0.412                              | 0.00058 | 1,249           | 1.58            | 0.255            |
| 2028          | 12,250                    | 0.00574                          | 0.0000397             | 17.0                             | 0.0217                           | 0.00346                          | 0.425                              | 0.00059 | 1,258           | 1.61            | 0.257            |
| 2029          | 12,576                    | 0.00607                          | 0.0000414             | 17.6                             | 0.0227                           | 0.00358                          | 0.437                              | 0.00060 | 1,268           | 1.64            | 0.258            |
| 2030          | 12,871                    | 0.00639                          | 0.0000431             | 18.1                             | 0.0236                           | 0.00369                          | 0.450                              | 0.00061 | 1,278           | 1.67            | 0.260            |
| 2031          | 12,729                    | 0.00647                          | 0.0000432             | 18.0                             | 0.0237                           | 0.00368                          | 0.461                              | 0.00062 | 1,286           | 1.69            | 0.262            |
| 2032          | 12,593                    | 0.00655                          | 0.0000433             | 18.0                             | 0.0238                           | 0.00366                          | 0.472                              | 0.00062 | 1,294           | 1.72            | 0.264            |
| 2033          | 12,329                    | 0.00656                          | 0.0000429             | 17.7                             | 0.0236                           | 0.00361                          | 0.483                              | 0.00063 | 1,301           | 1.74            | 0.265            |

**Table 2. Optional Low-NO<sub>x</sub> RNG Natural Gas Truck Tailpipe Emissions**

Southern California Gas Company  
 Los Angeles, California

| Calendar Year | Tailpipe Emissions (tons) |                |                 |                 |                  |
|---------------|---------------------------|----------------|-----------------|-----------------|------------------|
|               | NO <sub>x</sub>           | BC             | CO <sub>2</sub> | CH <sub>4</sub> | N <sub>2</sub> O |
| 2024          | 0.018                     | 0.000026       | 58.5            | 0.071           | 0.0119           |
| 2025          | 0.019                     | 0.000027       | 59.0            | 0.073           | 0.0120           |
| 2026          | 0.019                     | 0.000027       | 59.5            | 0.074           | 0.0121           |
| 2027          | 0.020                     | 0.000028       | 59.9            | 0.076           | 0.0122           |
| 2028          | 0.020                     | 0.000028       | 60.3            | 0.077           | 0.0123           |
| 2029          | 0.021                     | 0.000029       | 60.8            | 0.078           | 0.0124           |
| 2030          | 0.022                     | 0.000029       | 61.3            | 0.080           | 0.0125           |
| 2031          | 0.022                     | 0.000030       | 61.7            | 0.081           | 0.0126           |
| 2032          | 0.023                     | 0.000030       | 62.0            | 0.082           | 0.0126           |
| 2033          | 0.023                     | 0.000030       | 62.4            | 0.083           | 0.0127           |
| <b>Total</b>  | <b>0.206</b>              | <b>0.00028</b> | <b>605</b>      | <b>0.777</b>    | <b>0.123</b>     |

Constants:

Annual Truck Mileage<sup>2</sup>                      43,500 miles/year  
 BC Fraction in PM<sub>2.5</sub><sup>3</sup>                      0.200

Notes:

<sup>1</sup> Data estimated using EMFAC 2021 Database, available here:  
<https://arb.ca.gov/emfac/emissions-inventory/42a002799514c15e11132ea2b5e1765a99b219e5>. Modeled with a California Statewide region type, calendar year range 2024-2050, annual season, EMFAC202x vehicle category of T7 Tractor Class 8, model year 2024, and aggregate speed.

<sup>2</sup> CARB 2020 Low-NOx Omnibus Regulation defined useful life mileage for on-road HHDT vehicles. Available at:  
<https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2020/hdomnibuslownox/res20-23.pdf>

<sup>3</sup> For purposes of this analysis black carbon is used as a surrogate for elemental carbon. CARB's speciation profile for a static internal combustion engine is used to estimate elemental carbon emission factors. Available at:  
[https://ww3.arb.ca.gov/cc/inventory/slcp/doc/bc\\_inventory\\_tsd\\_20160411.pdf](https://ww3.arb.ca.gov/cc/inventory/slcp/doc/bc_inventory_tsd_20160411.pdf)

Abbreviations:

|                                       |  |
|---------------------------------------|--|
| CARB - California Air Resources Board | N <sub>2</sub> O - Nitrous oxide   |
| CH <sub>4</sub> - Methane             | NO <sub>x</sub> - Oxides of Nitrogen                                     |
| CO <sub>2</sub> - Carbon dioxide      | PM <sub>2.5</sub> - Particulate matter less than 2.5 microns in diameter |
| BC - Black carbon                     | RNG - Renewable Natural Gas  |
| EMFAC - Emission FACTors Model        | VMT - Vehicle Miles Traveled   |
| g - Gram                              | TOTEX - Total exhaust emissions  |
| HHDT - Heavy Heavy-Duty Truck         |  |

**Table 3. Diesel Fuel Efficiency and Upstream Emissions**

Southern California Gas Company  
Los Angeles, California

| Calendar Year | Diesel Fuel Consumption <sup>1</sup> | Diesel Fuel Efficiency | Upstream CO <sub>2</sub> e Emission Factors for Diesel <sup>2</sup> | Energy Consumption | Upstream CO <sub>2</sub> e Emissions |
|---------------|--------------------------------------|------------------------|---|--------------------|--------------------------------------|
|               | (1000 gal/day)                       | (mpg)                  | (g/MJ)  | (MJ/year)          | (ton/year)                           |
| 2024          | 36.9                                 | 7.17                   | 25.25   | 815,633            | 22.7                                 |
| 2025          | 49.7                                 | 7.16                   | 25.21   | 817,115            | 22.7                                 |
| 2026          | 50.7                                 | 7.16                   | 25.18   | 816,426            | 22.7                                 |
| 2027          | 57.1                                 | 7.18                   | 25.15   | 814,524            | 22.6                                 |
| 2028          | 64.2                                 | 7.20                   | 25.11   | 811,969            | 22.5                                 |
| 2029          | 65.8                                 | 7.22                   | 25.08   | 809,734            | 22.4                                 |
| 2030          | 67.3                                 | 7.23                   | 25.05   | 808,617            | 22.3                                 |
| 2031          | 66.6                                 | 7.23                   | 25.01   | 809,113            | 22.3                                 |
| 2032          | 66.1                                 | 7.21                   | 24.99   | 811,090            | 22.3                                 |
| 2033          | 64.9                                 | 7.19                   | 24.97   | 813,149            | 22.4                                 |
|               |                                      |                        |   | <b>Total</b>       | <b>224.9</b>                         |

Constants:

Annual Mileage<sup>3</sup> 43,500 miles/year  
 Diesel Energy Content<sup>4</sup> 134.47 MJ/gal

Notes:

<sup>1</sup> Annual diesel consumption estimated using EMFAC 2021 Database, available here: <https://arb.ca.gov/emfac/emissions-inventory/42a002799514c15e11132ea2b5e1765a99b219e5>. Modeled with a California Statewide region type, calendar year range 2024-2050, annual season, EMFAC202x vehicle category of T7 Tractor Class 8, model year 2024, and aggregate speed.

<sup>2</sup> Values calculated based on GREET model from Ramboll's Multi-technology pathway study. Emission factors between calendar year 2023-2031 and 2031-2037 are interpolated based on GREET outputs. Available online at: <https://www.wspa.org/wp-content/uploads/Multi-technology-Truck-Emission-Reduction-Scenarios-White-Paper-FINAL.pdf>

<sup>3</sup> CARB 2020 Optional Low-NO<sub>x</sub> Omnibus Regulation defined useful life mileage for on-road HHDT vehicles. Available at: <https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2020/hdomnibuslownox/res20-23.pdf>

<sup>4</sup> Unofficial electronic version of the Low Carbon Fuel Standard Regulation, 2020, Table 4: Energy Densities and Conversion Factors for LCFS Fuels and Blendstocks. Available at: [https://ww2.arb.ca.gov/sites/default/files/2020-07/2020\\_lcfs\\_fro\\_oal-approved\\_unofficial\\_06302020.pdf](https://ww2.arb.ca.gov/sites/default/files/2020-07/2020_lcfs_fro_oal-approved_unofficial_06302020.pdf).

Abbreviations:

CARB - California Air Resources Board gal - Gallon mpg - Miles Per Gallon  
 CO<sub>2</sub>e - Carbon Dioxide Equivalent HHDT - Heavy Heavy-Duty Truck NO<sub>x</sub> - Oxides of Nitrogen  
 EMFAC - Emission FACTors Model MJ - 10<sup>6</sup> Joule

**Table 4. Optional Low-NO<sub>x</sub> RNG Truck Fuel Efficiency and Upstream Emissions**

Southern California Gas Company  
Los Angeles, California

| Calendar Year | NG Fuel Consumption <sup>1</sup> | NG Fuel Efficiency | Upstream CO <sub>2</sub> e Emission Factors for Natural Gas <sup>2,3,4</sup> | Energy Consumption | Upstream CO <sub>2</sub> e Emissions |
|---------------|----------------------------------|--------------------|--|--------------------|--------------------------------------|
|               | (1000 gal/day)                   | (mpg)              | (g/MJ)   | (MJ/year)          | (ton/year)                           |
| 2024          | 1.09                             | 6.43               | 5.2  | 909,181            | 5.2                                  |
| 2025          | 1.48                             | 6.38               | 5.2  | 916,603            | 5.3                                  |
| 2026          | 1.52                             | 6.33               | 5.2  | 924,039            | 5.3                                  |
| 2027          | 1.73                             | 6.28               | 5.2  | 930,772            | 5.4                                  |
| 2028          | 1.96                             | 6.24               | 5.2  | 937,930            | 5.4                                  |
| 2029          | 2.03                             | 6.19               | 5.2  | 945,032            | 5.4                                  |
| 2030          | 2.09                             | 6.14               | 5.2  | 952,104            | 5.5                                  |
| 2031          | 2.09                             | 6.10               | 5.2  | 958,273            | 5.5                                  |
| 2032          | 2.08                             | 6.07               | 5.2  | 964,391            | 5.6                                  |
| 2033          | 2.04                             | 6.03               | 5.2  | 969,874            | 5.6                                  |
|               |                                  |                    |  | <b>Total</b>       | <b>54.2</b>                          |

Constants:

Annual Mileage<sup>5</sup>                      43,500 miles/year  
 Diesel Energy Content<sup>6</sup>              134.47 MJ/gal

Notes:

<sup>1</sup> Annual diesel-equivalent natural gas consumption estimated using EMFAC 2021 Database, available here: <https://arb.ca.gov/emfac/emissions-inventory/42a002799514c15e11132ea2b5e1765a99b219e5>. Modeled with a California Statewide region type, calendar year range 2024-2050, annual season, EMFAC202x vehicle category of T7 Tractor Class 8, model year 2024, and aggregate speed.

<sup>2</sup> Converted from electricity to Diesel Gallon Equivalent (DGE) using Fuel Conversion Factors provided by U.S Department of Energy.

<sup>3</sup> U.S Department of Energy, State & Alternative Fuel Provider Fleets, 2021. Fuel Conversion Factors to Gasoline Gallon Equivalents. Available at: <https://epact.energy.gov/fuel-conversion-factors>.

<sup>4</sup> CARB, LCFS Pathway Certified Carbon Intensities, 2021. Available at: <https://ww2.arb.ca.gov/resources/documents/lcfs-pathway-certified-carbon-intensities>.

<sup>5</sup> CARB 2020 Optional Low-NO<sub>x</sub> Omnibus Regulation defined useful life mileage for on-road HHDT vehicles. Available at: <https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2020/hdomnibuslownox/res20-23.pdf>

<sup>6</sup> Unofficial electronic version of the Low Carbon Fuel Standard Regulation, 2020, Table 4: Energy Densities and Conversion Factors for LCFS Fuels and Blendstocks. Available at: [https://ww2.arb.ca.gov/sites/default/files/2020-07/2020\\_lcfs\\_fro\\_oal-approved\\_unofficial\\_06302020.pdf](https://ww2.arb.ca.gov/sites/default/files/2020-07/2020_lcfs_fro_oal-approved_unofficial_06302020.pdf).

Abbreviations:

|   |                                 |                                      |
|---|---------------------------------|--------------------------------------|
| CARB - California Air Resources Board         | gal - Gallon                    | mpg - Miles Per Gallon               |
| CO <sub>2</sub> e - Carbon Dioxide Equivalent | HHDT - Heavy Heavy-Duty Truck   | NG - Natural Gas                     |
| EMFAC - Emission FACTors Model                | LCFS - Low Carbon Fuel Standard | NO <sub>x</sub> - Oxides of Nitrogen |
| g - Gram                                      | MJ - 10 <sup>6</sup> Joule      | RNG - Renewable Natural Gas          |

**Table 5. BEV-2024 Energy Efficiency and Upstream Emissions**

Southern California Gas Company  
Los Angeles, California

| Calendar Year | BEV Energy Consumption <sup>1</sup> | BEV Fuel Efficiency | BEV Fuel Efficiency <sup>2,3,4</sup> | Upstream CO <sub>2</sub> e Emission Factors for Electricity <sup>5</sup> | Energy Consumption | Upstream CO <sub>2</sub> e Emission |
|---------------|-------------------------------------|---------------------|--------------------------------------|--|--------------------|-------------------------------------|
|               | (kWh/day)                           | (mi/kWh)            | (mi/DGE)                             | (g/MJ)   | (MJ/yr)            | (ton/year)                          |
| 2024          | 22,843                              | 0.554               | 20.7                                 | 71.7   | 283,148            | 22.4                                |
| 2025          | 29,867                              | 0.554               | 20.7                                 | 68.2   | 283,150            | 21.3                                |
| 2026          | 27,762                              | 0.554               | 20.7                                 | 64.6   | 283,166            | 20.2                                |
| 2027          | 27,015                              | 0.554               | 20.7                                 | 61.0   | 283,244            | 19.0                                |
| 2028          | 25,110                              | 0.554               | 20.7                                 | 57.4   | 283,248            | 17.9                                |
| 2029          | 20,692                              | 0.554               | 20.7                                 | 53.8   | 283,251            | 16.8                                |
| 2030          | 17,275                              | 0.554               | 20.7                                 | 50.2   | 283,253            | 15.7                                |
| 2031          | 15,372                              | 0.554               | 20.7                                 | 46.6   | 283,251            | 14.6                                |
| 2032          | 15,209                              | 0.554               | 20.7                                 | 44.2   | 283,253            | 13.8                                |
| 2033          | 14,895                              | 0.553               | 20.6                                 | 41.8   | 283,319            | 13.1                                |
|               |                                     |                     |                                      |  | <b>Total</b>       | <b>174.7</b>                        |

Constants:

Annual Mileage<sup>6</sup>

43,500 miles/year

Diesel Energy Content<sup>7</sup>

134.47 MJ/gal

Conversion Factors:

32.3 kWh/GGE

1.155 GGE/DGE

Notes:

<sup>1</sup> Annual energy consumption estimated using EMFAC 2021 Database, available here: <https://arb.ca.gov/emfac/emissions-inventory/42a002799514c15e11132ea2b5e1765a99b219e5>. Modeled with a California Statewide region type, calendar year range 2024-2050, annual season, EMFAC202x vehicle category of T7 Tractor Class 8, model year 2024, and aggregate speed.

<sup>2</sup> Converted from electricity to Diesel Gallon Equivalent (DGE) using Fuel Conversion Factors provided by U.S Department of Energy.

<sup>3</sup> U.S Department of Energy, State & Alternative Fuel Provider Fleets, 2021. Fuel Conversion Factors to Gasoline Gallon Equivalents. Available at: <https://epact.energy.gov/fuel-conversion-factors>.

<sup>4</sup> CARB, LCFS Pathway Certified Carbon Intensities, 2021. Available at: <https://ww2.arb.ca.gov/resources/documents/lcfs-pathway-certified-carbon-intensities>.

<sup>5</sup> Values calculated based on GREET model from Ramboll's Multi-technology pathway study. Emission factors between calendar year 2023-2031 and 2031-2037 are interpolated based on GREET outputs. Available online at: <https://www.wspa.org/wp-content/uploads/Multi-technology-Truck-Emission-Reduction-Scenarios-White-Paper-FINAL.pdf>

<sup>6</sup> CARB 2020 Optional Low-NO<sub>x</sub> Omnibus Regulation defined useful life mileage for on-road HHDT vehicles. Available at: <https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2020/hdomnibuslownox/res20-23.pdf>

<sup>7</sup> Unofficial electronic version of the Low Carbon Fuel Standard Regulation, 2020, Table 4: Energy Densities and Conversion Factors for LCFS Fuels and Blendstocks. Available at: [https://ww2.arb.ca.gov/sites/default/files/2020-07/2020\\_lcfs\\_fro\\_oal-approved\\_unofficial\\_06302020.pdf](https://ww2.arb.ca.gov/sites/default/files/2020-07/2020_lcfs_fro_oal-approved_unofficial_06302020.pdf).

Abbreviations:

CARB - California Air Resources Board

BEV - Battery Electric Vehicle

CO<sub>2</sub>e - Carbon Dioxide Equivalent

DGE - Diesel Gallon Equivalent

EMFAC - Emission FACTors Model

g - Gram

GGE - Gasoline Gallon Equivalent

LCFS - Low Carbon Fuel Standard

kWh - 10<sup>3</sup> Watt-hour

MJ - 10<sup>6</sup> Joule

mi - Miles

mpg - Miles per Gallon

NO<sub>x</sub> - Oxides of Nitrogen



**Table 6. Estimation of Upstream Carbon Intensity for Optional Low-NO<sub>x</sub> RNG Truck**

Southern California Gas Company  
 Los Angeles, California

| Fuel Type                         | LCFS Sales Fraction <sup>1</sup> 2019-2020 | LCFS Certified CI <sup>2</sup> (gCO <sub>2</sub> e/MJ Fuel) |      |         |      |      | Weighted Average <sup>3</sup> |
|-----------------------------------|--|---|------|---------|------|------|-------------------------------|
|                                   |  | Min   | Max  | Average | Low  | High |                               |
| North American Landfill Gas (LFG) | 87%  | 7   | 83   | 45      | -342 | 45   | 5.23                          |
| Food Waste and Wastewater (WWTP)  | 4%   | -80   | 58   | -11     |      |      |                               |
| Dairy Digester/Animal Waste (AW)  | 10%  | -533  | -151 | -342    |      |      |                               |

Notes:

<sup>1</sup> CARB LCFS Reporting Tool Quarterly Summary, dated Jul 30, 2021. Available online at: [https://ww3.arb.ca.gov/fuels/lcfs/dashboard/quarterlysummary/20210730\\_q1datasummary.pdf](https://ww3.arb.ca.gov/fuels/lcfs/dashboard/quarterlysummary/20210730_q1datasummary.pdf).

<sup>2</sup> CARB, LCFS Pathway Certified Carbon Intensities, 2021. Available at: <https://ww2.arb.ca.gov/resources/documents/lcfs-pathway-certified-carbon-intensities>.

<sup>3</sup> Final upstream carbon intensity is obtained from the California Low-Carbon Fuel Standard program pathway lookup tables for the following RNG feedstocks: landfill gas, food wastes and animal waste/dairy digester gas. A weighted average of the carbon intensities is calculated based on the LCFS sales volumes in 2019-2020 and used in upstream RNG GHG calculations.

Abbreviations:

- |   |                                      |
|---|--------------------------------------|
| AW - Animal Waste                             | LCFS - Low Carbon Fuel Standard      |
| CARB - California Air Resources Board         | LFG - Landfill Gas                   |
| % - Percentage                                | MJ - 10 <sup>6</sup> joule           |
| CI - Carbon Intensity                         | NO <sub>x</sub> - Oxides of Nitrogen |
| CO <sub>2</sub> e - Carbon Dioxide Equivalent | RNG - Renewable Natural Gas          |
| g - Gram                                      | WWTP - Food Waste and Wastewater     |

**Table 7. Well-to-wheel Greenhouse Gas Emission Estimates for MY2024 Class 8 HHDT**

Southern California Gas Company  
 Los Angeles, California

| Parameter  | Units                            | Diesel Truck | Optional Low-NO <sub>x</sub> RNG Truck | Battery Electric Truck |
|--|----------------------------------|--------------|--|------------------------|
| Tailpipe CO <sub>2</sub> Emissions <sup>1,2</sup>                    | MT/truck                         | 614          | 0                                      | 0                      |
| Tailpipe CH <sub>4</sub> Emissions <sup>1</sup>                      | MT/truck                         | 0.00108      | 0.704                                  | 0                      |
| Tailpipe N <sub>2</sub> O Emissions <sup>1</sup>                     | MT/truck                         | 0.0967       | 0.112                                  | 0                      |
| Tailpipe BC Emissions <sup>1</sup>                                   | MT/truck                         | 0.00211      | 0.00026                                | 0                      |
| Total Tailpipe GHG Emissions <sup>3</sup>                            | MT CO <sub>2</sub> e /truck      | 645          | 51                                     | 0                      |
| Upstream GHG Emissions   | MT CO <sub>2</sub> e /truck      | 225          | 54                                     | 175                    |
| <b>Total Lifecycle GHG Emissions</b>                                 | <b>MT CO<sub>2</sub>e /truck</b> | <b>869</b>   | <b>105</b>                             | <b>175</b>             |
| Reduction of GHG Emissions Compared to a Diesel Truck                | MT CO <sub>2</sub> e /truck      | --           | 764                                    | 695                    |
| <b>Percent Reduction in GHG Emissions Compared to a Diesel Truck</b> | -                                | --           | <b>88%</b>                             | <b>80%</b>             |

Notes:

<sup>1</sup> Obtained from Table 1 and Table 2 for diesel and Optional Low-NO<sub>x</sub> RNG truck respectively. Tailpipe emissions for the battery electric truck are zero.

<sup>2</sup> Alternative fuels like RNG would result in elimination of tailpipe CO<sub>2</sub> emissions since fuels are plant/biogenically-based.

<sup>3</sup> Estimated as a sum of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emission using GWP values from IPCC AR4. Available at: [https://archive.ipcc.ch/publications\\_and\\_data/ar4/wg1/en/ch2s2-10-2.html](https://archive.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html). Accessed: September 2021.

<sup>4</sup> Obtained from Table 3, Table 4, and Table 5 for diesel and Optional Low-NO<sub>x</sub> RNG, and battery electric truck respectively.

| Greenhouse Gas   | 100-yr GWP <sup>3</sup> |
|------------------|-------------------------|
| CO <sub>2</sub>  | 1                       |
| CH <sub>4</sub>  | 25                      |
| N <sub>2</sub> O | 298                     |
| BC               | 900                     |

Conversion Factor:

1.10231 ton/MT

Abbreviations:

CARB - California Air Resources Board  
 % - percentage  
 BC - Black carbon  
 CEC - California Energy Commission  
 CH<sub>4</sub> - Methane  
 CO<sub>2</sub> - Carbon dioxide

CO<sub>2</sub>e - Carbon dioxide equivalent  
 GHG - greenhouse gas  
 GWP - Global warming potential  
 HHDT - Heavy-heavy duty truck  
 MT - Metric ton

N<sub>2</sub>O - Nitrous Oxide  
 NO<sub>x</sub> - Oxides of Nitrogen  
 RNG - Renewable Natural Gas  
 US EPA - United States Environmental Protection Agency

**Table 8. Lifetime Ownership Costs and Cost Effectiveness for MY2024 Class 8 HHDT**

Southern California Gas Company  
Los Angeles, California

| <b>Description</b>   | <b>Units</b>                 | <b>Diesel Truck</b> | <b>Optional Low-NO<sub>x</sub><br/>RNG Truck</b> | <b>Battery Electric Truck</b> |
|--|------------------------------|---------------------|--|-------------------------------|
| Total Cost of Ownership for Single Truck <sup>1</sup>              | \$                           | \$562,149           | \$480,576  | \$823,411                     |
| Additional Capital Cost for Battery Electric Truck <sup>2</sup>    | \$                           | --                  | --   | \$195,779                     |
| Total Cost of Ownership  | \$                           | \$562,149           | \$480,576  | \$1,019,190                   |
| Incremental Cost of Ownership                                      | \$                           | --                  | -\$81,573  | \$457,041                     |
|  | %                            | --                  | -15%   | 81%                           |
| Reduction in Lifecycle GHG Emissions Compared to Diesel            | MT CO <sub>2</sub> e         | --                  | 764  | 695                           |
| Reduction in Tailpipe NO <sub>x</sub> Emissions Compared to Diesel | tons                         | --                  | 1.0  | 1.2                           |
| <b>Cost Effectiveness for GHG Reductions</b>                       | <b>\$/MT CO<sub>2</sub>e</b> | <b>--</b>           | <b>-\$107</b>                                    | <b>\$658</b>                  |
| <b>Cost Effectiveness for Tailpipe NO<sub>x</sub> Reductions</b>   | <b>\$/ton</b>                | <b>--</b>           | <b>-\$83,935</b>                                 | <b>\$387,983</b>              |

Notes:

<sup>1</sup> Total costs of ownership for a single truck are taken from Ramboll's Multi-technology pathway study. Available online at: <https://www.wspa.org/wp-content/uploads/Multi-technology-Truck-Emission-Reduction-Scenarios-White-Paper-FINAL.pdf>. Accessed: September 2021.

<sup>2</sup> Per Giuliano et al. (2020), the truck fleet is anticipated to grow by approximately 40% when BEVs are used to replace diesel trucks in 2025, due to battery technology and charging constraints. We have therefore applied a factor 1.4 to the BEV capital costs to reflect added capital costs due to fleet growth if BEVs are used to replace all diesel trucks in 2024.

References:

Genevieve Giuliano, et al., Developing Markets for Zero Emission Vehicles in Short Haul Goods Movement: A Research Report from the National Center for Sustainable Transportation, 2020 November. Available at: <https://escholarship.org/uc/item/0nw4q530>. Accessed: September 2021.

Abbreviations:

- |   |  |
|---|--|
| \$ - 2018 US dollar                           | GHG - Greenhouse Gases                     |
| % - percentage                                | HHDT - Heavy-heavy duty truck              |
| BC - Black Carbon                             | kWh - 10 <sup>3</sup> Watt-hour            |
| BEV - Battery Electric Vehicle                | LCFS - Low Carbon Fuel Standard            |
| CARB - California Air Resources Board         | mpDGe - miles per diesel gallon equivalent |
| CH <sub>4</sub> - Methane                     | MT - Metric ton                            |
| CO <sub>2</sub> - Carbon dioxide              | N <sub>2</sub> O - Nitrous oxide           |
| CO <sub>2</sub> e - Carbon dioxide equivalent | NO <sub>x</sub> - Oxides of nitrogen       |
| GWP - Global warming potential                | RNG - Renewable Natural Gas                |

**Table 9. NO<sub>x</sub> Emission Estimates for MY2024 Class 8 HHDT**

Southern California Gas Company  
Los Angeles, California

|  | <b>Units</b> | <b>Diesel Truck</b> | <b>Optional Low-NO<sub>x</sub><br/>RNG Truck</b> | <b>Battery Electric<br/>Truck</b> |
|--|--------------|---------------------|--|-----------------------------------|
| Tailpipe NO <sub>x</sub> Emissions <sup>1</sup>                                  | tons         | 1.2                 | 0.2  | 0                                 |
| Incremental Reduction of NO <sub>x</sub><br>Emissions Compared to a Diesel Truck | tons         | --                  | 1.0  | 1.2                               |
| Percent Reduction of NO <sub>x</sub> Emissions<br>Compared to a Diesel Truck     | -            | --                  | 83%  | 100%                              |

Notes:

<sup>1</sup> Obtained from Table 1 and Table 2 for diesel and Optional Low-NO<sub>x</sub> RNG truck respectively. Tailpipe emissions for the battery electric truck are zero.

Abbreviations:

% - percentage

EMFAC - Emission FACTors Model

NO<sub>x</sub> - Oxides of Nitrogen

RNG - Renewable Natural Gas

**Table 10. Potential Emission Reductions from \$1Bn Investment into MY2024 Class 8 HHDT**  
 Southern California Gas Company  
 Los Angeles, California

| Truck Technology   |                      | Optional Low-NO <sub>x</sub> RNG Truck | Battery Electric Truck |
|--|----------------------|--|------------------------|
| <b>Capital Cost for Single Truck<sup>1</sup></b>                         | <b>\$/truck</b>      | <b>\$192,719</b>                       | <b>\$489,448</b>       |
| Number of Trucks Purchased   | --                   | 5,188                                  | 2,043                  |
| Reduction of BC Tailpipe Emissions Compared to Diesel <sup>2,3</sup>     | MT                   | 9.61                                   | 3.08                   |
| Reduction of Lifecycle GHG Emissions Compared to Diesel <sup>2,3</sup>   | MT CO <sub>2</sub> e | 3,963,507                              | 1,419,337              |
| Reduction of NO <sub>x</sub> Emissions Compared to Diesel <sup>3,4</sup> | tons                 | 5,042                                  | 1,719                  |

Notes:

<sup>1</sup> Total capital cost for a single truck is taken from Ramboll's Multi-technology pathway study. Available online at: <https://www.wspa.org/wp-content/uploads/Multi-technology-Truck-Emission-Reduction-Scenarios-White-Paper-FINAL.pdf>

<sup>2</sup> GHG emissions here include those contributed by black carbon. Values for CH<sub>4</sub>, BC, and GHG reductions per truck are referenced from Table 1.

<sup>3</sup> Because a Battery Electric Truck cannot haul the same amount as a diesel truck (weight and range limitations), the calculations assume that a single Battery Electric Truck replaces only approximately 0.7 diesel trucks. In addition, capital costs of BE trucks are greater than diesel trucks. Thus, a \$1B investment in Battery Electric Trucks will result in avoided diesel emissions from approximately 1,500 diesel trucks.

<sup>4</sup> NO<sub>x</sub> emission reductions per truck are referenced from Table 3.

Abbreviations:

\$ - 2018 US dollar

BC - Black Carbon

CH<sub>4</sub> - Methane

CO<sub>2</sub> - Carbon Dioxide

GHG - Greenhouse Gases

MT - Metric ton

NO<sub>x</sub> - oxides of nitrogen

RNG - Renewable Natural Gas

SLCP - Short Lived Climate Pollutants