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The Natural Gas Infrastructure and Decarbonization Targets (19-MISC-03)

Additional submitted attachment is included below.

David Hochschild, Chair
Andrew McAllister, Commissioner
California Energy Commission
1516 Ninth Street
Sacramento
California, 95814

June 21st, 2019

Re: The Natural Gas Infrastructure and Decarbonization Targets (19-MISC-03)

Dear Chair Hochschild and Commissioner McAllister,

The Lawrence Livermore National Laboratory (LLNL) appreciates the opportunity to comment on the Commission's recent workshop (June 6th, 2019) and proceeding on the natural gas infrastructure and decarbonization targets. LLNL believes that there may be important benefits to the state from achieving a low- or zero-carbon gas system. California's economic and climate goals may be best served by a combination of electrification and dramatic reductions in the carbon intensity of the existing gas network.

About LLNL

For more than 60 years, LLNL has applied science and technology to make the world a safer place. LLNL's defining responsibility is ensuring the safety, security and reliability of the nation's nuclear deterrent. Yet LLNL's mission is broader than stockpile stewardship, as dangers ranging from nuclear proliferation and terrorism to energy shortages and climate change threaten national security and global stability. Our mission is to strengthen the United States' security through development and application of world-class science and technology to enhance the nation's defense, reduce the global threat from terrorism and weapons of mass destruction, and respond with vision, quality, integrity and technical excellence to scientific issues of national importance.

Introduction

Climate change poses a real threat to California and the nation. The state has adopted ambitious policies to reduce greenhouse gas emissions. Notably, the state has undertaken to:

- Reduce greenhouse gas emissions 40% below 1990 levels by 2030 (SB32, 2016)

- Source 100% of retail electricity sales to California end-use customers and electricity procured to serve all state agencies from renewable energy resources and zero-carbon resources by 2045 (SB100, 2018)
- Reduce greenhouse gas emissions 80% below 1990 levels by 2050 (Executive Order S-3-05, 2005)
- Achieve economy-wide carbon neutrality by 2045 (Executive Order B-55-18, 2018)

It is firmly established that meeting these goals will require a broad set of tools and technologies, very likely also including technologies that have not yet been proven or deployed widely today.[1,2] In this vein, the state has come to consider the appropriate future for its natural gas infrastructure.

Even though fossil natural gas is less carbon intensive than oil and coal, it still contains carbon, and the associated emissions at today's levels are inconsistent with California's climate goals, both from a statutory perspective and from a climate perspective. However, there are control technologies as well as other pathways for producing and using methane that could render its use consistent with these goals. Furthermore, there are compelling reasons as to why an affirmative drive to phase out all existing natural gas infrastructure would be ill advised from a climate mitigation standpoint. We expand on these below focusing on key sectors in turn.

Expanding the Supply and Use of RNG and Hydrogen by Leveraging Natural Gas Infrastructure

Renewable Natural Gas (RNG) is methane that is generated from degradation of organic waste. It is sometimes regarded as a niche option in the decarbonization portfolio in California, due to its limited supply. California currently has the largest RNG potential in the United States and also has the largest number of natural gas refueling stations – a number that is predicted to rise.[3] Current estimates of RNG supply for California in 2030

[1] "Deep Decarbonization in a High Renewables Future - Updated Results from the California PATHWAYS Model", CEC-500-2018-012, June 2018: https://www.ethree.com/wp-content/uploads/2018/06/Deep_Decarbonization_in_a_High_Renewables_Future_CEC-500-2018-012-1.pdf

[2] "Optionality, Flexibility & Innovation - Pathways For Deep Decarbonization In California", Energy Futures Initiative (EFI), May 2019: https://static1.squarespace.com/static/58ec123cb3db2bd94e057628/t/5ced6fc515fcc0b190b60cd2/1559064542876/EFI_CA_Decarbonization_Full.pdf

[3] "The Feasibility of Renewable Natural Gas as a Large-Scale, Low Carbon Substitute", Amy Myers Jaffe, UC Davis:https://steps.ucdavis.edu/the-feasibility-of-renewable-natural-gas-as-a-large-scale-low-carbon-substitute/

are around 200 billion cubic feet per year,[4] comprising about 10% of 2016 consumption (2 trillion cubic feet).[5]

However, there are ways to significantly expand its supply beyond small applications like dairy digesters and landfill gas capture. Specifically, excess renewable power could be converted to RNG through methanation, or hydrogen through electrolysis. Several power-to-gas projects have demonstrated the technical feasibility of this today.[6] In addition, steam methane reforming can produce carbon-neutral hydrogen if process emissions are captured and geologically stored,[7] or even result in the removal of CO2 from the atmosphere if the methane source is biogenic.

Existing natural gas distribution infrastructure could also provide a platform to broaden the use of carbon-neutral or carbon-negative RNG. Renewable methane could replace fossil methane directly. In addition, hydrogen could be blended into existing natural gas distribution systems with little modification, or even completely replace fossil methane with larger modifications.[8] Scrapping the existing natural gas infrastructure would preclude both of these pathways. For reasons that we outline below, we consider this ill-advised at this point in time.

The Role and Future of Natural Gas in Electricity Production

Emissions from natural gas generation can be dramatically reduced

It is incorrect to assume that natural gas electricity generation has no role to play in a high-renewables, low carbon world. Such a view ignores key technological and economic dimensions. Current emission rates from single- and combined-cycle gas plants are inconsistent with mid-century climate stabilization and California's own goals. However, carbon capture and (geologic) storage of carbon dioxide (CCS) can significantly reduce or eliminate emissions from such plants. The technology for retrofitting existing plants (amine scrubbing) is available today.[9] We expect technological, efficiency and cost improvements to follow these first-generation retrofit solutions. New systems are

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[4] EFI, 2019.

[5] Data from the United States Energy Information Administration: https://www.eia.gov/dnav/ng/hist/na1490_sca_2a.htm

[6] European Power to Gas Platform: http://europeanpowertogas.com/projects-in-europe/

[7] The Port Arthur project in Texas has already successfully demonstrated the retrofitting of an existing steam methane reformer with carbon capture and geologic sequestration. See: Preston, Carolyn. (2018). 2018-05 The CCS Project at Air Products' Port Arthur Hydrogen Production Facility.

[8] "Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues", M. W. Melaina et al., Technical Report NREL/TP -5600-51995, March 2013: https://www.energy.gov/sites/prod/files/2014/03/f11/blending_h2_nat_gas_pipeline.pdf

[9] Several technology vendors will provide such systems, with commercial performance warrantees.

also being tested that could dramatically change the power generation paradigm, resulting in competitive, low/zero-carbon dispatchable electricity.[10]

Dispatchable, zero-carbon electricity can aid higher renewables penetration, reduce costs and safeguard grid stability

In order for a high degree of renewable penetration to be both technically feasible and affordable, the variability of wind and solar electricity generation must be managed. While several storage and other grid management options are available, the most economical pathway appears to be a generation mix that also includes small amounts of firm low-carbon sources such as natural gas and biofuels. Modeling by E3 indicates that such a system for California would feature 17-35 MW of natural gas generation.[11]

This finding supports nationally-applicable conclusions by Sepulveda et al. that the inclusion of firm low carbon sources reduces the cost of electricity by 10-60% in a fully decarbonized system.[12] According to their study, as CO2 emissions approach zero, the cost of decarbonization increases non-linearly due to the necessary buildout of solar and wind to meet peak electricity demand during periods of low generation. Significantly more renewable energy must be produced and stored to match the power capacity in firm low carbon sources. Wind and solar generation plus storage capacity would need to be 5-8 times peak demand. When natural gas or biofuels are included the installed generation would only need to be 1-2 times peak demand. The extensive build out of renewables would require 60-130% of total annual national electricity generation to be curtailed. The corresponding figure for California was estimated by E3 to be 50%.[13]

Natural gas also reduces the need for energy storage by allowing for dispatchable generation on a daily or seasonal basis. Though technically feasible, an electric grid comprised of renewables and a large storage resource would be subject to higher costs. According to the Clean Air Task Force, in a 100% renewable plus storage scenario, 36.4 million MWh of energy storage would be needed in California.[14] Battery technologies show diminishing returns at high inclusion levels in the grid. Large capital investments

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[10] An example is the Allam cycle technology currently being tested by NET Power.

[11] "Long-Run Resource Adequacy under Deep Decarbonization Pathways for California", E3, June 2019: https://www.ethree.com/wp-content/uploads/2019/06/E3_Long_Run_Resource_Adequacy_CA_Deep-Decarbonization_Final.pdf

[12] A. Sepulveda, Nestor & D. Jenkins, Jesse & J. de Sisternes, Fernando & K. Lester, Richard. (2018). The Role of Firm Low-Carbon Electricity Resources in Deep Decarbonization of Power Generation. Joule. 2. 10.1016/j.joule.2018.08.006.

[13] E3, June 2019.

[14] "The $2.5 trillion reason we can't rely on batteries to clean up the grid", J. Temple, MIT Technology Review, Jul27, 2018: https://www.technologyreview.com/s/611683/the-25-trillion-reason-we-cant-rely-on-batteries-to-clean-up-the-grid/

are needed to build sufficient storage that will have minimal year-round utilization, simply to be able to cope with the relatively scarce periods of low generation.

Since natural gas and biofuels are easily transportable and storable, they are available upon demand where needed, and can help provide operational flexibility and load-following capabilities that help maintain grid reliability and facilitate growth of intermittent renewables. This can ease the burden on Demand Response, which is estimated to be required on the order of 22 GWh of energy shifting alongside 11 GW of shedding by 2030.[15] A hedged approach of not relying on a single resource or technique would alleviate outcome risks and almost overall costs at the same time.

Decarbonizing Large Industrial Applications

In California, the industrial sector accounts for one-fifth of the state's greenhouse gas emissions as it produces materials like plastics, fertilizers and cement. Decarbonizing the industrial sector is challenging, as there are uses that demand large amounts of energy, often in the form of heat, that cannot be electrified in a practical way or made more efficient. Full electrification of other processes could increase electricity demands by 4-6 fold.[16]

The most economical pathway to reduce such industrial emissions is through a portfolio of decarbonizing technologies that include electrification, renewable natural gas, hydrogen, and carbon capture utilization and storage. Fuel switch to renewable natural gas, hydrogen, or electricity is a viable option that can significantly reduce emissions. Specifically, renewable natural gas can be a substitute for natural gas to reduce the carbon footprint of these industries without offshoring these industries and their emissions. The current natural gas infrastructure can be readily adapted to carry renewable natural gas with minimal infrastructure modifications.[17]

For many carbon-emitting California industries there are limited viable options for reducing their carbon emissions without completely reconstructing the industry – which could easily result in those industries being moved out of state. Cement making is an obvious example, but all industries that use significant amounts of heat face this issue. Developing low-carbon gas systems could solve those problems in ways that would minimize capital expenditure within the industry, while making possible a gradual transition that maintains jobs and capability without offshoring carbon emissions.

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[15] EFI, 2019.

[16] "Decarbonization of industrial sectors: The next frontier", McKinzey & Company, A. de Pee et al., June 2018: https://www.mckinsey.com/industries/oil-and-gas/our-insights/decarbonization-of-industrial-sectors-the-next-frontier

[17] NREL, 2013.

Decarbonizing the Transportation Sector

The transportation sector is responsible for the largest share of CO2 emissions in California, emitting ~40% of the State's greenhouse gas emissions.[18] Heavy-duty vehicles in particular comprise ~22% of vehicle transport[19] and are more difficult to decarbonize through electrification for a variety of reasons.[20,21] Li-ion batteries have an order-of-magnitude lower energy density compared to gasoline and other liquid fuels, and as such heavy-hauling vehicles require massive batteries which can decrease payload. These vehicles are also run at more intensive utilization factors, making charging time a bigger factor than in light-duty vehicles.

Advancements in battery technologies are ongoing, and several all-electric heavy-duty vehicles are in development today. Nonetheless, we cannot reliable predict the pace of economic electrification of heavy-duty vehicles. To complement the transition to a lower-carbon heavy-duty fleet, RNG can be used to drive down emissions using existing technologies, and can even serve as a retrofit solution on existing diesel vehicles. RNG can also replace fossil LNG and CNG in natural gas vehicles without modification.

Existing natural gas pipeline and fueling infrastructure, coupled with RNG supply, could therefore serve as another tool for reducing emissions from the state's transportation sector.

The Right Path for the Building and Residential Sector

California's buildings contribute to 9.2% of California's greenhouse gas emissions, primarily from fossil natural gas used in space/water heating and cooking.[22] California's residential sector is highly reliant on natural gas: 88% of homes consume natural gas, with 2/3 of homes using natural gas for space heating, 84% for water heating.[23] In total, 8 million furnaces in California consumed 172 billion cubic feet of natural gas.[24]

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[18] "California Greenhouse Gas Emission Inventory - 2018 Edition", California Air Resources Board: https://www.arb.ca.gov/cc/inventory/data/data.htm

[19] EFI 2019, compiled using data from CARB, 2018.

[20] "Comparing the powertrain energy and power densities of electric and gasoline vehicles", R. Vijayagopal, Argonne National Laboratory, 20 July 2016: http://www.umtri.umich.edu/sites/default/files/Ram.Vijayagopal.ANL_.PTS21.2016.pdf

[21] "Electrification Futures Study: End-Use Electric Technology Cost and Performance Projections through 2050", P. Jadun et al., National Renewable Energy Laboratory, 2017: https://www.nrel.gov/docs/fy18osti/70485.pdf

[22] EFI, 2019, compiled from CARB, 2018.

[23] EFI, 2019, citing IEA, 2009.

[24] EFI, 2019, citing IEA, 2009.

E3's presentation at the Jun6th, 2019 workshop indicated that full electrification of California's buildings may be the lowest cost option to reduce associate emissions. We do not question that conclusion, but note that factors other than cost may affect complete electrification in a suitable timeframe.

While new buildings are most easily electrified, current buildings are reliant on natural gas and would require replacement of existing equipment for electrification. Residential natural gas equipment can have a lifetime of decades. Replacing it with electrically powered equipment may also require electrical wiring upgrades. Also, consumer choice may affect the pace and degree of electrification: while some consumers may not favor gas over electric water heaters, preference for gas over electric cooking stoves may be particularly strong.

Furthermore, until electricity is completely decarbonized (current state target is 2045), full electrification of buildings does not reduce greenhouse gas emissions to zero. The emissions from current residential natural gas demand could be significantly reduced while maintaining current residential infrastructure by blending RNG into the natural gas supply. For example, EFI, using data from Navigant predicts that in 2030 CA has enough RNG supply potential to provide at least 23% of total natural gas used in buildings.[25]

Conclusion and Recommendations

In summary, there are up-sides to maintaining existing natural gas infrastructure that cut across many sectors. Several of these sectors are particularly challenging to decarbonize, such as heavy-duty vehicle transportation and large-scale industrial heat. Even for sectors and applications that are technologically more straightforward and cheaper to electrify, such as residential heating or cooking, there are merits to allowing multiple lines of attack.

In the comments above we have singled out some of the challenges that are inherent in the most commonly touted alternative to natural gas infrastructure: electrification. We do presuppose that these challenges cannot be overcome from a technological, economic or logistical standpoint, nor that they are unique to electrification. In fact, the existing natural gas infrastructure suffers from problems of its own, such as the need for ongoing maintenance and the well-documented presence of methane leaks, which lead to potent climate forcing. We are also aware that maintaining existing gas infrastructure relies on contributions from ratepayers (although it is not clear that such contributions could readily be diverted in their entirety towards electrification efforts – so the inherent degree of "tension" between the two approaches is debatable).

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[25] EFI, 2019 (p.215).

Rather, we contend that striving to predict the shortcomings, likely uptake levels and costs of each approach is wrought with problems and uncertainty, and that a strategy that hedges against the risks of coming up short on emission reductions does not pre-select a single winner to the exclusion of all other contributors, but instead banks on a portfolio of possible solutions.

To that effect, setting sectoral performance standards or emission reduction goals and letting all mitigations options compete and contribute would promote the largest levels of decarbonization while minimizing the risk of failure to achieve the desired emissions outcome. No matter how rigorous a modeling exercise may be at this point in time, we are dealing with a complex system with an inherent degree of uncertainty. A performance-based approach would be more robust in the face of the economic and technological uncertainty factors present in this area.[26] An example of such a policy is California's Low Carbon Fuel Standard, which sets declining carbon intensity targets for the state's fuels sector. The approach and policy could be replicated for the buildings sector, or for industrial applications and emissions, for example.

We thank the Commission for taking a close look at this important topic.

Respectfully submitted,

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[26] "Decision Making under Deep Uncertainty - From Theory to Practice", V. A. W. J. Marchau et al., 2019: https://link.springer.com/content/pdf/10.1007%2F978-3-030-05252-2.pdf