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Subject: Comments on the 2018 Integrated Energy Policy Report (IEPR) Update Joint Agency Workshop on Achieving Zero Emission Buildings, Docket # 18-IEPR-09

Southern California Gas Company (SoCalGas) appreciates the opportunity to comment on the Achieving Zero Emissions Buildings workshop conducted by the California Energy Commission (CEC) as part of the 2018 IEPR Update proceeding. We offer comments for your consideration on the following:

I. Renewable Natural Gas—A Smart Solution to Reduce Greenhouse Gas (GHG) Emissions in Buildings
II. Integrating Diverse and Flexible Resources to Support the Grid
    a. *Power-to-Gas and microgrids*
    b. *Combined heat and power generation systems can support the grid*
    c. *Natural gas fuel cells*
III. Building Electrification Challenges
    a. The full cost of electrification needs to be further examined
    b. California must adopt policies that can be replicated elsewhere
IV. Upstream Methane Emissions
V. Building Decarbonization and Air Quality

I. Renewable Natural Gas—A Smart Solution to Reduce GHG Emissions in Buildings

SoCalGas supports the state's efforts to curb greenhouse gas (GHG) emissions. We have long been a leader in developing emerging technology and energy efficiency (EE) programs that deliver meaningful emissions reductions. While we are proud of the advances we have achieved through our programs and partnerships with equipment manufacturers and our customers, we recognize the multifaceted challenges presented in achieving the mandated GHG emissions reduction targets by 2030.

Many of the parties at the workshop were focused on a singular solution – electrify all buildings. However, if the goal is to make significant strides to combat climate change a multifaceted approach that considers all pathways to lower the carbon intensity of residential and commercial buildings should be taken. During the CEC's presentation on Building Decarbonization, Martha Brook provided an overview of the Pacific Coast Collaborative's commitment to lower the carbon intensity of heating fuels in residential and commercial buildings. Three main pathways to reach thermal decarbonization were presented: 1.) Electrification, 2) Renewable Gas, and 3) Energy Efficiency.

The CEC has conducted recent workshops under the IEPR Update proceeding this year to further explore two of the three main pathways to achieve significant reductions in the carbon intensity of the commercial and residential building sector (Doubling EE Savings Workshop on June 7, 2018 and Achieving Zero Emissions Buildings Workshop on June 14, 2018). However, we encourage the CEC to further examine the role renewable natural gas (RNG) can play in thermal decarbonization. As called out in the 2018 IEPR Update Scoping Order, "the long-term role of natural gas in California buildings" should be discussed and "market barriers, data collection needs, building performance metrics, and grid integration opportunities to develop recommendations that advance California's energy-related policies and programs on [GHG] reductions from buildings" should be identified.

Natural gas provides valuable, low-cost energy to customers. Californians also prefer the use of natural gas for heating and cooking in all regions of the state and they overwhelmingly oppose mandates to get rid of their natural gas appliances, with particular concerns about energy costs and choice.[1] Asking customers to make major renovations to their homes for new equipment could create challenges in adopting the new technologies. The amount of incentives to achieve mass electrification has not been studied and could be very costly. While the state agencies study the electrification approach, we should move forward with utilizing RNG with the support of the California Public Utilities Commission (CPUC), California Air Resources Board (CARB), and other state agencies.

CARB identified a number of different approaches for "achieving success in clean energy" in their latest Climate Change Scoping Plan Update, including renewable electricity, implementing the EE action plan, and reduce the use of heating fuels while concurrently making what is used cleaner by minimizing methane leaks, prioritizing natural gas efficiency and demand reduction, and enabling cost-effective access to renewable gas.[2]

An important part of CARB's strategy in the Scoping Plan is putting waste resources to beneficial use, including organic sources of methane from waste streams. It is well documented that the largest methane emissions in California come from the agricultural and waste sectors.[3] Capturing these emissions is integral to lowering methane emissions in California in a reasonable and economic way.[4] The existing natural gas infrastructure provides a solution to reduce emissions from these sectors by transporting RNG over existing, safe transmission and distribution infrastructure. These efforts would have the added benefit of promoting economic development and energy reliability in California by developing new renewable energy sources.

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[1] California Building Industry Association. January 2018. *California Natural Gas Poll.*
[2] California's 2017 Climate Change Scoping Plan Update, ES-11. Accessed from https://www.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf.
[3] Proposed Final 2017 IEPR, p. 279 (See also https://www.arb.ca.gov/board/books/2017/092817/17-9-5pres.pdf).
[4] See October 2, 2017, Introduction to the Phase I Report of the California Methane Survey from the Staff of the California Air Resources Board, available at https://www.arb.ca.gov/research/methane/CA_CH4_Survey_Phase1_Report_2017.pdf.

As directed by Senate Bill (SB) 1383, CARB's Short-Lived Climate Pollutant Reduction Strategy (SLCP) requires a 40% reduction in methane emissions by 2030. The majority of these emissions come from California's waste stream, which includes organic sources of methane from sewage, landfills, dairies, and agriculture. Reducing these emissions and delivering RNG to buildings for energy end uses will help achieve critical climate change objectives.

SoCalGas has requested an analysis by Navigant Consulting to look at how the use of more efficient natural gas appliances and RNG can help to achieve carbon emissions reductions in buildings. In the first phase of the study, Navigant looked at the amount of RNG to achieve emissions reductions comparable to electrification of residential appliances. The analysis showed that California can achieve comparable carbon reductions to building electrification by introducing increasing amounts of RNG into the natural gas supply. For example, assuming 30% of buildings could be electrified by 2030, this is equivalent to displacing 5% of natural gas supply with RNG. Navigant is currently finalizing a second phase of this study that shows the relative cost of different scenarios for electrification and RNG, which SoCalGas will plan to share with the CEC in the next few weeks. We believe this new study will provide another viewpoint on reaching our 2030 targets.

During the public comment period, one of the parties suggested there is insufficient RNG supplies to achieve building decarbonization. They focused on a limited subset of RNG feedstocks within California. However, there have been multiple studies evaluating in- and out-of-state RNG resources that demonstrate there are sufficient supplies available to decarbonize gas delivered to buildings. CEC examined in-state resources in the 2017 IEPR to advance the objectives of SB 1383 to reduce in-state methane emissions.[5] However, there are considerable supplies that can be transported through the existing interstate pipeline network for use in California. SoCalGas has attached a memo prepared by ICF that summarizes several national and statewide studies on available feedstocks (Attachment 1).

SoCalGas welcomes a more robust conversation on in- and out-of-state RNG resources within the context of this IEPR Update. We would also note that Energy and Environmental Economics (E3) indicated during the workshop that they are currently performing a more detailed study on the availability and costs of RNG and synthetic gas resources as part of their study on the Future of Natural Gas, which will be provided to the CEC in 2019.

Currently, SoCalGas is supporting legislation to create a procurement program for natural gas utilities to purchase RNG as part of their procurement portfolio. The program would ramp up to 5% of core throughput by 2030. We believe that market stability through a utility procurement requirement is necessary to increase production, drive down costs over time, develop new gasification and other renewable gas technologies, and provide the volumes of RNG necessary to move it to the core market. This will drive greater GHG reductions without the massive disruption and investment that would be required for individual customers to replace existing equipment and appliances.

Furthermore, it is important to note that energy leaders in other parts of the world, particularly in Europe and Canada, are also looking at RNG as a pathway to decarbonize the gas supply and achieve thermal decarbonization. France has adopted a renewable gas standard that calls for RNG to make up at least 30 % of natural gas consumption by 2030. Énergir, a

[5] See 2017 IEPR, Chapter 9, Table 20 on p. 254 for a summary of in-state resources based on three different studies. https://efiling.energy.ca.gov/getdocument.aspx?tn=223205

Canadian natural gas utility, has a target to distribute 5 % of RNG by 2025 and is working towards efforts to have a fully developed RNG marketplace by 2020. SoCalGas has just announced a collaboration with several utilities in Europe and Canada to advance the development of policies and technologies to support decarbonizing natural gas supplies. "The development of renewable gas is a real challenge for the energy transition and has a key role to play in the context of the low carbon strategy. The signing of this partnership agreement at the World Gas Conference reflects our shared desire to develop green gas and associated technologies and facilitate its production and injection into natural gas networks," said Christophe Wagner, International Director for GRDF.[6]

Internationally, the United Nations Climate Change Council and the World Green Building Council have set goals for buildings to achieve net zero by 2050.[7,8] In Europe, countries are looking at renewable electricity and RNG to deliver the energy needs of the building sector. For California to depart from the international community's consensus, by setting a new target for zero emissions, is a mistake, especially given extensive natural and RNG delivery capability and the very high market penetration of natural gas use in residential buildings (Links to several studies on the use of RNG abroad are provided in Attachment 2). As we transition to low-carbon energy, gas and electric systems need to work in harmony. Natural gas and RNG will be an essential partner to renewables in balancing the electricity system.

SoCalGas recommends that the CEC support facilitating long-term supply contracts, which would enable capital financing of long-term production projects and provide further market certainty for the renewable gas market. The capture and productive use of organic sources of methane re-uses California's waste streams as energy, which is critical in reducing fugitive methane emissions in the state. We need policies to support the broader use of RNG, such as those that encourage its use in buildings to reduce GHG emissions.

Deep reductions in carbon intensity will best be achieved by decarbonizing both electric and gas supplies. An integrated energy grid, comprised of both electric and gas delivery systems that are increasingly renewable and lower carbon, can ensure reliability, and help society adapt and become more resilient to the impacts of climate change.

In addition to the three thermal decarbonization approaches supported by the Pacific Coast Collaborative, SoCalGas suggests an additional approach for consideration: explore how microgrids can enhance reliability and resiliency as we transition to cleaner energy use in California's buildings. This is further discussed in Section II below.

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[6] Press release by SoCalGas, Energir, GRDF and GRTgaz (Attachment 3)

[7] Twitter. UN Climate Change. Available at https://twitter.com/UNFCCC/status/1004664904719224833

[8] World Green Building Council. June 2018. *World Green Building Council Calls on Companies Across the World to Make their Buildings Net Zero Carbon.* Retrieved from http://www.worldgbc.org/news-media/world-green-building-council-calls-companies-across-world-make-their-buildings-net-zero.

II. Integrate Diverse and Flexible Distributed Energy Resources to Support the Electric Grid

a. *Power-to-Gas and microgrids*

SoCalGas has submitted extensive comments in the past[9] on the opportunity for Power-to-Gas (P2G)[10] technology to convert surplus renewable energy into hydrogen, which can be blended with natural or renewable gas and utilized in everything from home appliances to power plants. The renewable fuel can also be converted to methane for use in a natural gas pipeline and storage system or used in hydrogen fuel cell vehicles.

We would like to further elaborate on how P2G can support microgrids, which are improving the reliability and resiliency of the electric sector and decarbonizing building energy use. SoCalGas commissioned a demonstration project at the University of California, Irvine (UCI) to show the feasibility of P2G to capture and return excess renewable power to a microgrid. The UCI campus microgrid is comprised of photovoltaics (PV), a thermal energy storage system with district heating and cooling, a natural gas combined cycle (NGCC) cogenerating plant, and a lithium ion battery energy storage system serving a community of more than 30,000 people and encompassing a wide array of building types, and transportation options. The newest addition to the UCI campus microgrid is a P2G system that uses a polymer electrolyte membrane electrolyzer to convert excess renewable power into hydrogen gas. The hydrogen gas is injected into the campus pipeline system where it is blended with natural gas. The hydrogen/natural gas blend is then used to power the onsite NGCC system.

The UCI system demonstrates several of the value propositions that P2G technology can provide for microgrids, including a dispatchable load, the capture of otherwise-curtailed intermittent renewable power, and using the natural gas system as a storage resource for excess renewable energy. The integration of the campus' electric microgrid and natural gas distribution system has allowed the campus to decarbonize the electricity and natural gas serving buildings on the campus. Dr. Jack Brouwer made a presentation during the 2017 IEPR Renewable Gas Workshop describing the increased utilization of the campus' solar grid by integrating P2G into their operations.[11]

b. *Combined heat and power generation systems can support the grid*

Small combined heat and power generation systems (microCHP) can provide highly efficient, localized electrical power for lighting, air conditioning and building systems, while capturing waste heat for domestic hot water, food service, laundry, swimming pools, and other heating loads. SoCalGas partnered with Brookfield Residential to develop a 75 kilowatt (Kw) microCHP system currently in use at the Resort at Playa Vista in the City of Los Angeles is 85%

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[9] SoCalGas. Comments in response to the 2015 IEPR Draft AB 1257 Report, the 2017 IEPR Increasing the Need for Flexibility in the Electricity System Workshop held on 5/12/17, and the Draft 2017 IEPR.

[10] SoCalGas website. Available at https://www.socalgas.com/smart-energy/presentations-webinars/decarbonizing-the-pipeline.

[11] Presentation by Jack Brouwer at June 26, 2017 IEPR workshop https://efiling.energy.ca.gov/GetDocument.aspx?tn=220149

efficient when fully utilized and uses an advanced internal combustion engine and exhaust catalyst technology to combust natural gas, meeting the South Coast Air Quality Management District's (SCAQMD) stringent emissions limits for criteria pollutants.[12] The system is integrated with the building's solar PV system to provide balanced energy night and day. Utilizing RNG would provide an additional opportunity to decarbonize the building energy supply.

c. *Natural gas fuel cells*

SoCalGas has recently partnered with a national production homebuilder to design and build a fully integrated 1.5 kW fuel cell in a new construction demonstration home. The fuel cell utilizes natural gas to produce clean electricity and heat at over 80% efficiency, using a non-combustion, electro-chemical reaction, with low GHG emissions and virtually zero nitrogen oxides (NOx). The home will utilize the fuel cell in conjunction with solar PV and other smart home energy management technologies to achieve extremely low emissions and energy use. Combined with RNG, fuel cell technology would allow the home to achieve zero net carbon emissions as well. Furthermore, SoCalGas has been working in partnership with UCI to test and develop this technology, and will continue to seek technology demonstration and partnership opportunities with original equipment manufacturers, builders, and other commercial entities to bring this product to full market production.

III. Building Electrification Challenges

a. The full cost of electrification needs to be further examined

To date, we have an incomplete record on the full cost of electrification to an individual consumer. As acknowledged by the panelist from the Sacramento Municipal Utility District, the study they presented looked at some costs associated with equipment replacement. However, the cost figures did not capture the total cost of ownership. Full costs include ancillary systems, including ducting, wiring extension, and electrical panel upgrades for increased amperage needs in homes.

In March 2018, the California Building Industry Association (CBIA) funded Navigant Consulting to study the potential costs customers could incur from switching from a mixed-fuel home to an all-electric one.[13] In Phase I of the study, Navigant looked at existing single-family homes in several Southern California locations. They found that by "[s]witching to all-electric

[12] Shiau and Wang. 2018. 2018 West Coast Energy Management Congress Conference Proceedings (Seattle, WA). "Pivotal Roles of Combined Heat and Power in A Commercial Near-Zero Net Energy Facility Demonstration at Playa Vista".
[13] Navigant Consulting. April 19, 2018. *The Cost of Residential Appliance Electrification, Phase 1 Report- Existing Single-Family Homes.*

appliances would cost CA consumers over $7200 and increase energy costs by up to $388 per year."[14,15]

To achieve a 2% decrease in statewide GHGs emissions from residential buildings[16] (6% of current total state GHG emissions),[17] homeowners would need to pay about $2,600 to purchase and install new electric appliances as well as about $4,600 to upgrade their home's wiring and electric panels to handle the additional electrical load. Also, the net annual increase in utility costs from increased electrical consumption is up to $388 per home. The homeowners' $613-$877 combined annual cost increase represents about 1-2% of median household income for California customers. This would result in an annual cost increase of $4.3- $6.1 billion across California's seven million single-family homes.

SB 350 calls for improving economic conditions in disadvantaged communities;[18] therefore, CEC must consider electrification impacts to the affordability of energy and housing for the 43% of California households that are lower income,[19] including nearly one-third of SoCalGas customers—or 1.5 million households—that receive bill assistance each month.

SoCalGas urges the CEC to continue on the path of balanced energy, allowing builders, designers, and homeowners to utilize all available resources, from higher-efficient energy systems to multiple fuel sources, both for conventional use and renewable generation systems. This approach fosters innovation, competition, and flexibility, while still advancing California's energy policies. SoCalGas also recommends the CEC fund studies to further explore how electric heat pump use would affect utility bill costs to minimize speculation around affordability and determine the associated effects in grid-wide peak shifting and demand response.

b. CPUC Incentives for All-Electric Homes

SoCalGas is concerned that some of the proposals contained in the CPUC's presentation (Building Electrification and the CPUC) start to diverge from previously established statutes and policies. For example, energy efficiency program funds are required to be spent in a cost-effective manner. Any activities, including the support of zero-emission building activities, or otherwise, must pass the cost-effectiveness rigor to be eligible for energy efficiency incentives. SoCalGas is fully supportive of energy efficiency and other demand-side management activities as a pathway for California to meet its environmental and clean energy goals. These objectives must be achieved in a cost-effective way, as has been the long-standing policies of both the CEC and the CPUC. SoCalGas does not support deviation from these principles as an undue burden would be placed on utility customers and ratepayers.

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[14] This analysis does not include the cost of necessary infrastructure upgrades to the local and statewide electricity grid to accommodate the additional load on the system.
[15] Navigant Consulting. California Building Industry Association. April 2018. *The Cost of Residential Appliance Electrification, Phase I Report, Existing Single-Family Homes.*
[16] Ibid.
[17] CARB Website. Available at https://www.arb.ca.gov/cc/inventory/data/data.htm.
[18] California Public Utilities Commission. 2018. Disadvantaged Communities. Retrieved from http://www.cpuc.ca.gov/General.aspx?id=6442453417
[19] California Department of Housing and Community Development. January 2017. *California's Housing Future: Challenges and Opportunities, Public Draft Statewide Housing Assessment 2025.* Retrieved from http://www.hcd.ca.gov/policy-research/plans-reports/docs/California's-Housing-Future-Main-Document-Draft.pdf

Similarly, SoCalGas is concerned with the CPUC's suggestions of creating new tariffs with discounted rates for all-electric customers. Their presentation indicates they would recover the under-collection from dual-fuel customers. This sort of subsidization of one type of ratepayer by another class of ratepayer creates poor price signals for all-electric customers and could create financial burdens on low income customers, if they are unable to take advantage of the lower rate offerings by electric utilities. Likewise, SoCalGas would want to ensure natural gas ratepayers are no put in a position to subsidize electric ratepayers through incentive programs or other mechanisms.

The CPUC needs to examine all aspects of policy decisions that would shift away from long-standing principles to encourage conservation, energy efficiency and rate equity.

c. *California must adopt policies that can be replicated elsewhere*

California has long been a leader in addressing climate change and reducing GHG emissions via setting targets, spurring technology development, and setting new standards for buildings. Many, if not most, of the steps we take in the energy and environmental arena have ripple benefits across the country and beyond. However, a recent Forbes article noted there are many unique characteristics about California that make it challenging for other states and regions to replicate.[20] For example, Californians benefit from the availability of solar, while other regions have not adopted renewable portfolio standards in part due to the lack of available renewable resources. If other states cannot generate the same level of renewables in the electric sector, then a push towards electrifying buildings will not be an effective strategy to reduce GHGs in other regions.

The American Gas Association estimates that over 60% of homes nationally use natural gas. Over 90% of customers in Southern California use natural gas for space and water heating. Therefore, we ask the CEC, would California's fast transition to the electrification of buildings provide leadership for other parts of our country? We believe the answer is no, and that encouraging efficiency improvements in gas appliances and encouraging a reduction in the carbon intensity of natural gas, via RNG, could enable the state to continue to be a strong leader in reducing GHG emissions in buildings across the nation.

IV. Upstream Methane Emissions

Mr. Andrew Mrowka from CARB gave a presentation on methane emissions during the workshop. He talked about the full lifecycle emissions from the production and delivery of fossil natural gas. It is important to understand that the majority of upstream emissions occur in the production and gathering of fossil natural gas. As we move towards RNG, we will displace fossil natural gas delivered to California and avoid these upstream fugitive emission sources. Mr. Mrowka also discussed the important work being done by CARB and CPUC to address fugitive emissions from natural gas systems in California.[21] SoCalGas would like to take this opportunity to share with the CEC some of the key points to consider about fugitive emissions from the

[20] Forbes. Keeping California's Great Solar Boom in Perspective. Accessed from https://www.forbes.com/sites/judeclemente/2018/06/01/keeping-californias-great-solar-boom-in-perspective/#31bffe6f113c

[21] SB1371 (http://www.cpuc.ca.gov/General.aspx?id=8829); Oil and Gas Regulation (https://www.arb.ca.gov/regact/2016/oilandgas2016/oilandgas2016.htm)

natural gas distribution system and the advances California utilities are already undertaking to reduce methane emissions.

SoCalGas' natural gas system has one of the lowest methane emission rates in the country, despite it being the largest– a system of more than 100,000 miles of pipeline, spanning 20,000 square miles and serving 21 million consumers. Pursuant to SB 1371, SoCalGas submits a Natural Gas Leakage Abatement Report to the CPUC annually. This report provides a comprehensive summary of SoCalGas' efforts to reduce fugitive methane emissions from our system. According to the Short Lived Climate Pollutant Plan, natural gas pipelines account for 9% of the in-state methane emissions, which is roughly 8.8% of total GHG emissions[22]. Based on these values, methane emissions from SoCalGas' system would be less than 0.3% of the total inventory. SoCalGas has a long-standing commitment to modernizing its system infrastructure to increase safety and reliability and reduce methane emissions. Some of the most effective steps SoCalGas has taken include:

- Eliminating cast iron pipe from our system;
- Modernizing equipment in our Metering and Regulating facilities to utilize zero or lower emitting devices than previously available;
- Implementing the Vintage Plastic Replacement Program;
- Implementing the Bare Steel Replacement Program;
- Implementing the Distribution Integrity Management Program;
- Implementing operational procedures to minimize gas vented to atmosphere during routine maintenance and other operational activities; and
- Prioritizing the replacement of pipe that does not meet current standards for the prevention of corrosion.

The modernization of equipment, the use of best management practices and technology to minimize emissions during maintenance and operational procedures, and the prioritized replacement of pipeline without current corrosion control technologies continues today. In addition, SoCalGas takes many steps to reduce emissions across its system, from our transmission pipelines and underground storage facilities, to distribution lines and customer meter sets. These initiatives include:

- Performing annual leak surveys on certain pipelines;
- Repairing leaks in our non-hazardous leak backlog;
- Lowering pipeline pressure when feasible during planned natural gas releases;
- Using a methane capture system when feasible to collect gas during pipeline maintenance and reinjecting it back into the system; and
- Identifying and replacing certain pneumatic devices with lower-emissions devices.

SoCalGas and the other utilities in California have been leaders in adopting best practices and developing technologies to detect and reduce emissions related to our operations. These efforts to reduce upstream emissions will help contribute to the decarbonization of buildings.

[22] CARB. Short Lived Climate Pollutant Plan, p. 56, Figure 4. https://www.arb.ca.gov/cc/shortlived/meetings/03142017/final_slcp_report.pdf

V. Building Decarbonization and Air Quality[23]

There were several speakers during the workshop who made comments about air quality and indoor air quality. SoCalGas would like to provide clarifications on several of these points. Ms. Brook presented a slide entitled ‘Fossil Fuels and Buildings,’ and noted that 93% of Californians live in ozone non-attainment areas. While, this point is unfortunately true, the majority of emissions contributing to high ozone levels comes from the transportation sector—not emissions associated with buildings. For example, in SCAQMD and the San Joaquin Valley Air Pollution Control Districts (SJVAPCD), the two extreme non-attainment areas, 90% of NOx emissions, a precursor to ozone, comes from the transportation sector.

The local air districts and CARB continue to push for reductions in emissions from all sectors, including residential and commercial buildings. SoCalGas has worked with several manufacturers to develop cleaner residential furnaces, which reduce NOx emissions by 65%. SCAQMD has recently established an incentive program to facilitate a market transition to these cleaner furnaces. SoCalGas continues to work with the local air districts and equipment manufacturers to reduce emissions through improvements in burner technology and energy efficiency.

We would also like to provide clarification and refute statements that natural gas cooking appliances are a public health concern. It is the emissions from the cooking process, and not from burner or heat source operations that represent the chief source of concern with respect to indoor air quality.[24] A recent study by the CEC states that “exposure to pollutants from natural gas can result from three general scenarios:

- Improper or ineffective venting of exhaust gases from appliances required to be vented;
- Using cooking burners without venting or with ineffective venting; and
- Using illegal vent-free heaters or fireplaces.”[25]

In addition, according to CARB, “[t]he act of cooking itself, whether with gas or electric stovetop burners or ovens, can also generate elevated levels of most of these pollutants, due to heating oil, fat, and other food ingredients, especially at high temperatures … and [s]tudies have revealed that home air pollutant levels can exceed health-based standards when people are cooking in kitchens with poor ventilation.”[26] Without proper ventilation, cooking indoors with either electric or natural gas appliances can create air quality concerns. SoCalGas is committed to customer safety and following all California building code regulations and combustion appliance safety protocols.

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[23] Statements that the use of natural gas appliances affected indoor air quality were made by panelists during the workshop. This section provides additional information refuting those claims.

[24] California Air Resources Board. January 2006. Residential Cook Exposure Study Final Report. Retrieved from https://www.arb.ca.gov/research/indoor/cooking/cooking.htm.

[25] California Energy Commission. October 2017. Emissions, Indoor Air Quality Impacts, and Mitigation of Air Pollutants from Natural Gas Appliances. Retrieved from http://www.energy.ca.gov/2017publications/CEC-500-2017-034/CEC-500-2017-034.pdf.

[26] California Air Resources Board Website. “Cooking and Range Hoods.” Retrieved on 6/13/2018 from https://www.arb.ca.gov/research/indoor/cooking/cooking_range_hoods.htm.

VI. Conclusion

SoCalGas provides these comments to help move California towards meeting our aggressive climate goals in a thoughtful, reasoned, studied, and cost-effective way. We believe that we can decarbonize buildings by decarbonizing electricity and natural gas supplies—not just electrifying end uses. We provide several strategies that can help move us forward including developing the market for renewable natural gas; utilizing distributed generation resources like combined heat and power systems; exploring Power-to-Gas technology to help integrate the electric and natural gas grid providing long-term energy storage and decarbonized conventional natural gas supplies.

We know natural gas will continue to play an important role in electric generation over the long-term future – and not just for central power plants. Carbon capture and carbon use technologies will move into commercial deployment to assist the state in de-carbonizing its central station generating sector. But new, appropriately scaled and flexible gas peaking technology will become more available, balancing the intermittency of renewables, helping to integrate them into the grid, and growing our renewable generation portfolio over the long term.

The year 2030 is approaching very quickly and we need to look at all opportunities to reduce emissions. California must remain a leader in addressing climate change and should adopt policies that can be replicated outside of California and the country. As the CARB presenters noted during the morning session of the workshop, EE plays a critical role in meeting our targets. Building envelope improvements coupled with decarbonizing the fuel we use in buildings remains paramount in meeting the state's GHG emission reduction goals. We need to look at how to decarbonize natural gas, not just electrify end-uses. And we need sensible policies that are cost-effective and preserve customer choice while meeting our GHG emissions reduction goals.

Sincerely,

George Minter
Regional Vice President, External Affairs & Environmental Strategy
Southern California Gas Company

SoCalGas Comments on the 2018 IEPR Update Joint Agency Workshop on Achieving Zero Emission Buildings, Docket # 18-IEPR-09

Appendix 1

ICF Study: Re-Assessment of Renewable Natural Gas

MEMORANDUM

To: Allison Smith, SoCalGas

From: Philip Sheehy

Date: February 2016

Re: Re-Assessment of Renewable Natural Gas

Introduction

Renewable natural gas (RNG) is produced over a series of steps – namely collection of a feedstock, delivery to a processing facility for biomass-to-gas conversion, gas conditioning, compression, and injection into the pipeline. In this memo, ICF focuses on the availability of various feedstocks at the California state-level and at the national level for conversion to RNG. ICF's resource assessment focused on the following four studies:

- BAC/University of California, Davis (UC-Davis), White Paper (November 2014). Note that the BAC white paper draws from an analysis performed by UC-Davis.[1]
- National Petroleum Council (NPC), An Overview of the Feedstock Capacity, Economics, and GHG Emission Reduction Benefits of RNG as a Low-Carbon Fuel (March 2012)
- American Gas Foundation (AGF), The Potential for Renewable Natural Gas: Biogas Derived from Biomass Feedstocks and Upgraded to Pipeline Quality (September 2011).
- U.S. Department of Energy (DOE), Billion Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry (DOE BT) (August 2011).

Feedstocks Considered

RNG can be produced from a variety of renewable feedstocks, including the following:

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[1] Data from this study are a mix of publicly available documents regarding UC Davis's assessment a draft version of UC Davis's 2013 resource assessment, recently published by the California Energy Commission (CEC).

Table 1. Renewable Natural Gas Feedstocks

Feedstock for RNG	Description
Agricultural residue	The material left in the field, orchard, vineyard, or other agricultural setting after a crop has been harvested. Inclusive of unusable portion of crop, stalks, stems, leaves, branches, and seed pods.
Animal manure	Manure produced by livestock, including dairy cows, beef cattle, swine, sheep, goats, poultry, and horses.
Energy crops	Energy crops are inclusive of perennial grasses, trees, and some annual crops that can be grown specifically to supply large volumes of uniform, consistent quality feedstocks for energy production.
Fats, oils, and greases (FOGs)	Long chain fatty compounds that are byproducts of cooking, such as fryer grease (yellow grease) and grease traps (brown grease).
Forestry and forest product residue	Biomass generated from logging, forest and fire management activities, and milling. Inclusive of logging residues (e.g., bark, stems, leaves, branches), forest thinnings (e.g., removal of small trees to reduce fire danger), and mill residues (e.g., slabs, edgings, trimmings, sawdust). Includes materials from public forestlands (e.g., state, federal), but not specially designated forests (e.g., roadless areas, national parks, wilderness areas) and includes sustainable harvesting criteria as described in the U.S. Department of Energy *Billion Ton Update* (see below).
Landfill gas (LFG)	The anaerobic digestion of biogenic waste in landfills produces a mix of gases, including methane (40-60%).
Municipal solid waste (MSW) (compost or lignocellulosic)	Refers to the organic fraction of waste which is typically landfilled, such as food waste and some yard trimmings. Does not include portion that is used in other industries, such as composting. Refers to the organic fraction of waste which is typically landfilled, such as paper products, certain yard trimmings (e.g., branches), and construction and demolition debris. Does not include portion that is used in other industries.
Wastewater treatment (WWT) gas	Wastewater consists of waste liquids and solids from household, commercial and industrial water use. In the processing of wastewater, a sludge is produced, which can be anaerobically digested to produce methane.

Feedstocks are generally harvested and/or collected for delivery to a centralized facility for pre-processing and/or treatment before being converted to natural gas (and other reaction products).

Conversion Technologies

RNG production is largely produced via two conversion technologies: anaerobic digestion or thermal gasification.

- **Anaerobic digestion (AD)** is the process whereby microorganisms break down organic material in an environment without oxygen. In the context of RNG production, the process generally takes place in a controlled environment, referred to as a digester or reactor. When organic material is introduced to the digester, it is broken down over time (e.g., days) by microorganisms, and the gaseous products of that process contain a large fraction of methane and carbon dioxide.

- **Thermal gasification (TG)** describes a broad range of processes whereby a carbon-containing feedstocks are converted into a mixture of gases referred to as synthetic gas or syngas, including hydrogen carbon monoxide, steam, carbon dioxide, methane, and trace amounts of other gases (e.g., ethane, hydrogen sulfide, and nitrogen). The process occurs at high temperatures (650–1350°C) and varying pressures (depending on the gasification system. There is limited commercial-scale deployment of TG technologies.

After conversion, the product gases require other processes which may include methanation, conditioning, clean-up, and compression prior to being injected into the pipeline for delivery to the end-user. In many cases, RNG projects require some investment in interconnection e. g., distribution pipelines that connect to a natural gas transmission pipeline network.

RNG Resource Assessment

The table below highlights the scope of each study in terms of a) feedstocks and b) geography.

Table 2. Scope of Biogas Resource Assessments Considered by ICF by a) Feedstock and b) Geography

Study	Feedstock								Geography	
	Ag Residue	Animal Manure	Energy Crops	FOGs	Forestry Residue	LFG	MSW	WWT Gas	US	CA
BAC/UC Davis										
NPC 2012										
AGF 2011										
DOE BT 2011										

California Biogas Resource Assessment

The table below includes California's biogas production potential, broken down by feedstock in units of trillion Btu (tBtu) for each of the studies considered; the table also includes ICF's recommended range of biogas production based on our review of the studies and their respective methodologies.

Table 3. ICF RNG Resource Assessment, California (in units of tBtu)

Feedstock	BAC / UC DAVIS	AGF[1]		DOE BT[2, 3]		ICF Assessment of Existing Studies	Notes/Comments
		low	high	low	high		
Agricultural Residue	31.0	4.2	10.6	30.7	33.7	30.7–33.7	Significant competition likely with liquid biofuel sector.
Animal Manure	19.4	8.7	29.0	2.3	10.3	12.8–19.4	Recommend the UC Davis as a high value, scaling down the AGF study slightly.
Energy Crops[4]	73.5	0.0	0.0	0.0	0.0	n/a	The most recent version (Mar 2015) of "An Assessment of Biomass Resources in California" did not assess dedicated biomass energy crops.
Fats, Oils and Greases	6.4	n/a	n/a	n/a	n/a	n/a	The BAC report links FOGs to biodiesel conversion. And since it is not included in any other study, we exclude it from consideration here.
Forestry and Forest Product Residue	80.9	4.9	12.2	9.2	15.0	15.0–46.6	Significant competition likely with liquid biofuel sector. The UC Davis study likely over-estimates the potential of forest residue based on ICF review of DOE BT updated approach.
Landfill Gas	52.1	28.4	56.8	n/a	n/a	22.8–56.8	ICF recommendation based on combination of *high Btu* LFG projects in California and the assumption that other landfill gas capture projects can be converted over time.
MSW (food, leaves, grass)	12.1	7.8	23.3	12.1	14.1	23.3–52.0	Although the UC Davis numbers are higher than other studies considered, ICF does not have sufficient reasoning for a reduced high potential.
MSW (lignocellulosic)	39.9			10.3	17.7		
WWT Gas	7.5	0.3	0.8	n/a	n/a	4.2–7.5	UC Davis has much higher estimates than AGF; however, it is unclear why. Insufficient reasoning to revise potential downward.
Total Potential (tBtu)	***322.8***	***54.3–132.7***		***67.2–98.6***		***108.8*–216.0**	ICF's range of recommended values reflects variation in studies reviewed and consideration of potential competition for feedstocks; however, these estimates were not developed using a comparative cost-benefit analysis or techno-economic assessment of feedstock and conversion technologies.

1. The low and high values in the AGF study represent what the study refers to as *non-aggressive* and *aggressive* scenarios. The low/non-aggressive scenario assumes roughly 5-25% (depending on resource) of biomass is processed into RNG. The high/aggressive scenario assumes 15-75% (depending on resource) of biomass is processed into RNG.
2. The DOE BT study did not estimate yields of biogas. The focus of the study is on the *feedstock* rather than the *finished fuel*. ICF used conversion efficiencies from the UC Davis work to estimate the tBtu of finished fuel (in this case, biogas) based on the feedstock potential reported in the DOE BT study.
3. The low and high values from the DOE BT study represent the available feedstock assuming a price of $40/ton in 2015 and a price of $80/ton in 2030.
4. Energy crops were not identified in the BAC White Paper; nor were they included in the most updated UC Davis report available.

Feedstock Competition

It is important to note that one cannot assume that any of these feedstocks are freely available for biogas production. Many of these feedstocks are currently used for other purposes and therefore the price of the feedstock will largely depend on the cost of replacing the feedstock with another material. For example, animal manure is widely used as an alternative to chemical fertilizers. The cost of the animal manure will largely depend on the current market price of synthetic fertilizer. A brief list of feedstock competitors is included in the table below and discussed in more detail in the subsequent sub-sections.

Table 4. Competition for RNG Feedstocks

Feedstock	Competition
Agricultural Residue	Animal feed; livestock bedding (e.g., straw from grains); liquid biofuels (e.g., POET-DSM); carbon sequestration, and; benefits to agricultural land such as reduced soil erosion, soil nutrient recycling, and maintenance of soil organic matter and fertility.
Animal Manure	Fertilizers and compost materials; electricity production (e.g., poultry litter), and; manure being diverted for existing anaerobic digestion systems.
Energy Crops	Electricity production and liquid fuels production.
Fats, Oils and Greases	Animal feed; liquid biofuels production (e.g., biodiesel), and; cosmetics and soaps.
Forestry and Forest Product Residue	Electricity production; fuel for boilers, kilns, dryers; pulp-and-paper; pellet and briquette manufacturing; landscaping (e.g., bark chips); fertilizer for forest land; particleboard manufacturing, and; animal bedding (e.g., shavings and sawdust).
Landfill Gas	Electricity production; industrial process heat; existing LFG contracts for biogas.
Municipal Solid Waste (food, leaves, grass, lignocellulosic)	Recycling; fertilizer production through composting (e.g., food scraps, yard trimmings), and; waste-to-energy (i.e., heat, electricity).
WWT Gas	Fuel for WWTP process heat, and; electricity production.

Many of these feedstocks are also being used to generate electricity to meet state Renewable Portfolio Standard (RPS) targets. The California RPS requires that in-state electric utilities have 33% of retail sales derived from eligible renewable energy resources by December 31, 2020 and all subsequent years, within incremental targets starting in 2013. Eligible renewable energy technologies include certain biomass resources, including "agricultural crops, agricultural wastes and residues, waste pallets, crates, dunnage, manufacturing, construction wood wastes, landscape and right-of-way tree trimmings, mill residues that result from milling lumber, rangeland maintenance residues, biosolids, sludge derived from organic matter, wood and wood waste from timbering operations, and any other materials under Public Resources Code Section 40106."[2] Other biomass including landfill gas, biomethane, and municipal solid waste conversion are also eligible.[3]

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[2] See "Renewables Portfolio Standard Eligibility" pg. 9 for a complete list: http://www.energy.ca.gov/2013publications/CEC-300-2013-005/CEC-300-2013-005-ED7-CMF-REV.pdf

[3] There are strict in-state requirements for tracking and verifying the quantities and sources of biomethane and deliveries from dedicated pipelines, common carrier pipelines, or certain on-site production facilities.

Feedstock-Specific Considerations in Resource Assessment

The following sub-sections highlight the key aspects ICF considered when developing our California in-state resource assessment. Broadly speaking, we considered a) methodological aspects of each study and b) potential competition for feedstocks. Where possible, we have provided current pricing data for feedstocks.

Agricultural Residue

ICF has no objections to the resource assessments for agricultural residues; however, ICF notes that the technically recoverably volumes of agricultural residue will be difficult to convert into biogas with high efficiency. For instance, the agricultural residues outlined in the UC Davis study include orchard and vineyard crops, field and seed crops, vegetable crops, and food and fiber residues. UC Davis assumed that 70% of orchard and vineyard crops, 50% of field and seed crops, 5% of vegetable crops, and 80% of food and fiber residues were technically recoverable for purposes of energy production. The UC Davis study does not account for existing competition for those feedstock sources: Many residues are currently plowed back in the soil to serve as fertilizer and recycle nutrients, reduce soil erosion, and maintain organic matter levels. Many residues are also used for animal feed and livestock bedding (e.g., straw from grains). Furthermore, there will likely be competition for residues from liquid biofuels. The numbers presented in the BAC White Paper, for instance, support this viewpoint, which assumes the lignocellulosic portion of residues converted into ethanol.

For illustrative purposes, we consider wheat straw as a potential feedstock. At the field-level, the farmer will likely consider the value of wheat straw as a soil enriching agent. Wheat straw has moderate levels of nitrogen and potassium, but low levels of phosphate. Using current pricing (as of Q1 2016) for these fertilizers and the amount of each in a ton of wheat straw, the economic value of the wheat straw as a fertilizer is around $10/ton. That price excludes any costs of removing that wheat straw from the field, delivering it to a facility, and other considerations. Regardless, our point is that this is the first step in the process of determining how these residues might be valued at the field- or farm-level.

Animal Manure

ICF recommends a more cautious approach to the resource assessment for animal manures outlined in the BAC report and the AGF Report. While ICF agrees with the methodology employed in both the AGF study and the UC Davis study, neither takes into account competing uses for the manure. As mentioned in the feedstock competition section previously, manure is typically land-applied as an alternative to synthetic fertilizers. Manure may also be used for electricity production, particularly from poultry litter which is largely composed of wood chips or sawdust used for bedding, or already dedicated to existing anaerobic digestion systems. However, it is reasonable to assume that manure not used for electricity or existing systems could capture a higher value as a biogas feedstock compared to fertilizer and therefore could be diverted depending on demand. This unmitigated manure could also generate carbon mitigation credits for programs like California's Carbon Cap and Trade program and/or provide negative carbon intensities for programs like the LCFS due to the capture and utilization of methane that is currently being vented to atmosphere.

Energy Crops

ICF recommends excluding energy crops from consideration as a California-based resource. Both the AGF and DOE-BT studies indicated that there is no potential for energy crops in California. Further, in a previous report to the CEC, UC Davis writes (***emphasis*** added):

> Dedicated biomass crops are not currently grown to any significant extent in California. There is some potential that they will develop in combination with phytoremediation efforts for contaminated lands such as salt-affected soils in the San Joaquin Valley. Sugar and starch crops may develop to support the production of ethanol and other biofuels and bioproducts. Residues from these crops could be used for

> power generation or the fuel products used directly. Dedicated crop production could lead to crop shifting on existing agricultural lands but might also be associated with more marginal lands. This analysis includes a dedicated biomass crop category producing 5 million BDT/y by 2017 with an availability of 90%, recognizing that *this constitutes a highly uncertain source of supply*. The production would likely occur logistically. The analysis here assumes an average yield of 5 BDT/acre. *Water may be a key limiting resource in this production.*

Furthermore, ICF notes that in the most recent resource assessment (2013), UC Davis excluded energy crops from consideration. Given the uncertainty associated with the potential for energy crops in California, the current drought conditions in California, and the exclusion of this resource from other studies, ICF recommends a conservative approach that assumes no potential for energy crops in California.

There are significant potential resources outside of California, however, with the DOE-BT study indicating that more than 600 MDT of energy crops could be available in 2030. For the other feedstocks considered, there was little variation between resource availability in 2020 compared to 2030. In the case of energy crops, however, the resource availability increases by a factor of two (2).

Fats, Oils, and Greases (FOGs)

The BAC report is the only study that we reviewed that included an estimate of FOGs. They estimated 207,000 tons of FOGs available in California for the production of 56 million gasoline gallon equivalent (GGE) of biofuels (specifically biodiesel). This analysis was based on a 1999 report commissioned by the National Renewable Energy Laboratory (NREL) and performed by Appel Consultants. The BAC report assumes each Californian produces 11.2 pounds (lbs) per person per year of FOGs among a California population of 36.96 million.[4] The FOGs documented in this study included yellow grease (primarily from restaurant fryers) and trap grease (grease from sinks and dishwashers that is trapped in a containment unit of a restaurant before entering the sewer system). This study was based on 30 randomly selected metropolitan areas in the United States. The only city in California included in the study was Sacramento, which had a yellow grease and trap grease production average of 3.04 and 11.2 lbs per person per year (lbs/person/yr) respectively.

Trap grease is typically not considered an optimal feedstock for biodiesel due to the high levels of contaminates. These contaminates are difficult to remove and may ultimately impact the quality of the biodiesel. ICF contends that only the yellow grease portion would realistically be available for biodiesel production. Using the Sacramento average of 3.04 lbs./person/yr and a revised California population of 38.33 million based on the 2013 census, the total resource would be closer to 58,000 tons of biodiesel. Using the BAC calculation of 7.5 lbs. FOG per gallon of finished biodiesel and one diesel gallon equivalent (DGE) equal to 1.12 GGE, the revised total would be closer to 17.4 M GGE.

It is possible that urban waste grease could be used in anaerobic digesters to produce biogas. However, with the high commodity price of yellow grease close to $400/ton (as of January 2016),[5] it is far more likely that yellow grease would be used in the biofuel or animal feed market. It is possible that trap grease could be used in anaerobic digesters as it has negligible value, but contaminants, including cleaning detergents, could kill microbes essential to biogas production making it an unlikely feedstock.

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[4] Wiltsee, G. (1999). Urban Waste Grease Resource Assessment: NREL/SR-570-26141. Appel Consultants, Inc. 11.2 lbs/ca-y FOG and California population of 36.96 million. Biodiesel has ~9% less energy per gallon than petroleum diesel.

[5] Jacobsen Report, Animal Fats & Oil: FOG West Coast, January 2016.

Forestry and Forest Product Residue

There are approximately 40 million acres of forest lands in California. Approximately 46% is national forest, 12% is other public forest, and 42% is private forest. ICF follows the recommendations from the U.S. Department of Energy (DOE) U.S. Billion Ton Study Update[6] in 2011, which estimated the in-state resource to be between 1.8 and 2.4 million bone dry tons per year (MBDT/yr) for biomass up to $80/ton with the low estimate without federal lands and the high estimate with federal lands. The estimate included integrated composite operations, other removal residues, conventional wood, logging residues, simulated thinnings from forestlands, and treatment thinnings (e.g., fire hazard thinnings).

These estimates contrast with those in the UC Davis report[7] commissioned by CEC and account for four main categories of forestry biomass: logging slash (e.g., branches, tops, bark); forestry thinnings (e.g., understory brush, small diameter trees, other non-merchantable materials); sawmill residues (e.g., bark, sawdust, planer shavings, trim ends), and; shrub or chaparral (e.g., shrub biomass obtained from habitat improvement activities like thinning, fuel treatment operations to reduce wildfire risk). The UC Davis resource estimates were based on information from the California Department of Forestry and Fire Protection (CAL FIRE) [8] Fire and Resource Assessment Program and sawmill residues were developed from the 2003 timber harvest and residue data.[9] The UC Davis study estimated the technical potential for forestry products to be approximately 14.2 MBDT/yr.

However, unlike the DOE BT study, the UC Davis study did not account for the overlap between forest materials that might be taken under a commercial harvest operation and forest materials that might be taken for fire threat reduction scenarios. This overlap has been estimated in the CAL FIRE report to be about 53,000 BDT/yr (about 26,000 BDT/yr merchantable timber and 27,000 BDT/yr of non-merchantable material), and is removed from the CALFIRE estimates for harvest potential. Revised CAL FIRE assessments were approximately 4.2 MBDT/yr.

The DOE Billion Ton study also altered the original methodology to include additional sustainability criteria. Some of the changes included: [10]

- Alterations to the biomass retention levels by slope class (e.g., slopes with between 40% and 80% grade included 40% biomass left on-site, compared to the standard 30%).
- Removal of reserved (e.g., wild and scenic rivers, wilderness areas, USFS special interest areas, national parks) and roadless designated forestlands, forests on steep slopes and in wet land areas (e.g., stream management zones), and sites requiring cable systems.

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[6] U.S. Department of Energy, "U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry," 2011. https://www.bioenergykdf.net/content/billiontonupdate.

[7] California Energy Commission, "An Assessment of Biomass Resources in California, 2007, 2010, and 2020," prepared by University of California, Davis, December 2008. http://www.energy.ca.gov/2013publications/CEC-500-2013-052/CEC-500-2013-052.pdf.

[8] California Department of Forestry and Fire Protection, "Biomass potentials from California forest and shrublands including fuel reduction potentials to lessen wildfire threat," Draft PIER Consultant Report, Contract 500-04-004, February 2005. See page 34 and Table 15. http://frap.fire.ca.gov/publications/BIOMASS_POTENTIALS_FROM_CA_FOREST_AND_SHRUBLANDS_OCT_2005.pdf.

[9] Yang, P. and B.M. Jenkins. 2005. Wood residue generation from sawmills in California. Draft report,

California Biomass Collaborative, University of California, Davis, CA.

[10] Bryce Stokes, Department of Energy, "2011 Billion Ton Update – Assumptions and Implications Involving Forest Resources," September 29, 2011, http://web.ornl.gov/sci/ees/cbes/workshops/Stokes_B.pdf.

- The assumptions only include thinnings for over-stocked stands and didn't include removals greater than the anticipated forest growth in a state.
- No road building greater than 0.5 miles.

ICF believes the additional sustainability criteria provide a more realistic assessment of available forestland. Unlike the UC Davis study, the DOE Billion Ton study also includes resource costs.

Another study performed by the Western Governors' Association estimate California's resource to be closer to 1.3-5.1 MBDT/yr ranging from $10/ton to $100/ton for forestry residues including fire hazard thinnings, logging residue, treatment of Pinyon Juniper woodland, thinnings on private timberland, and mill residues.[11] At a price of $50/ton the base case estimate was 4.1 MBDT/yr and the high case estimate was 4.9 MBDT/yr.

It is important to note that these estimates were developed for liquid biofuels, not biogas. It is possible that biogas could be generated from forestry resources using thermal gasification technologies. However, thermal gasification technologies are more expensive than anaerobic digestion, less efficient (range of 60% to 70% depending on the process), and typically produce undesirable by-products, such as tars and oils. According to the National Petroleum Council, thermal gasification of woody biomass to produce biogas is at the pre-commercial stage. Commercial-scale implementation is expected around 2020.[12]

Pricing for forest and forest product residues is complicated. For instance, in California, pricing is determined across 9 regions (see map in figure below) and for various types of products, including:

- Miscellaneous harvest: Includes special items such as Christmas trees, fuelwood, chipwood, poles and pilings, posts, split products, small sawlogs, cullogs and miscellaneous conifers.
- Green Timber: Defined as trees that are health and, in the opinion of a Registered Professional Forester (RFP) or Professional Arborist, have a high likelihood of surviving 12 months or more if not harvested.
- Salvage Timber: Includes only dead, dying, fatally damages, or downed trees removed from an area of salvage logging.

California's Board of Equalization posts prices by region and product time on a quarterly basis (for tax purposes). These prices are shown for harvested wood in units of thousand board feet (MFB, a board foot is 1ft x 1ft x 1in) or linear feet (LF). This is effectively untreated wood, and has not been dried or treated for biomass processing – regardless if it is a gasification or liquefaction. The tables

Figure 1. Timber Value Areas in California, BOE

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[11] Western Governors' Association, "Strategic Assessment of Bioenergy Development in the West," September 2008. http://www.fpl.fs.fed.us/documnts/pdf2008/fpl_2008_gordon001.pdf. See Tables 8 and 9.

[12] Renewable Natural Gas for Transportation: An Overview of the Feedstock Capacity, Economics, and GHG Emission Reduction Benefits of RNG as a Low-Carbon Fuel, National Petroleum Council, March 2012: http://www.npc.org/FTF_Topic_papers/22-RNG.pdf.

below include the so-called Harvest Value Schedule for July 1, 2015 through December 31, 2015.[13]

Table 5. Miscellaneous Harvest Values in California, July-December 2015

Species or Product	UNIT	Harvest Value ($ per unit)
Christmas trees, Natural Misc.	Linear Feet	0.60
Christmas trees, Natural Red Fir	Linear Feet	1.40
Christmas trees, Natural White Fir	Linear Feet	0.60
Christmas trees, Plantation	Linear Feet	1.50
Cull logs	Adj. Gross M board feet	5.00
Fuelwood, hardwood	Cords	20.00
Fuelwood, miscellaneous	Cords	10.00
Pulp chipwood & hardwood logs	Green Tons	1.00
Woods-produced fuel chips	Bone Dry Tons	0.00
Poles & pilings, small DF (20’-50’)	Net M board feet	270.00
Poles & pilings, large DF (51’ - up)	Net M board feet	290.00
Poles & pilings, PP, TF (all sizes)	Net M board feet	190.00
Posts, round	8 Linear feet	0.20
Split products, redwood	Net M board feet	75.00
Split products, miscellaneous	Net M board feet	10.00
Small sawlogs, miscellaneous 1/	Net M board feet	90.00
Miscellaneous conifer species	Net M board feet	80.00

Table 6. Green Timber (via Tractor Logging), California July-December 2015

SPECIES	PER LOG	SIZE CODE	Time Value, By Area								
			1	2	3	4	5	6	7	8	9
Ponderosa Pine	Over 300	1	210	180	80	280	320	340	330	230	230
	150-300	2	160	170	60	230	290	310	260	200	190
	Under 150	3	110	110	30	140	240	280	250	190	80
Hem/fir	N/A	N/A	200	150	N/A	180	260	210	240	220	160
Douglas-fir	Over 300	1	380	270	120	350	390	370	380	300	N/A
	150-300	2	340	260	110	330	370	340	340	290	N/A
	Under 150	3	320	180	80	310	350	310	320	280	N/A
Incense Cedar	N/A	N/A	70	100	N/A	160	280	310	270	270	220
Redwood	Over 300	1	650	690	560	N/A	N/A	N/A	N/A	N/A	N/A
	150-300	2	540	630	550	N/A	N/A	N/A	N/A	N/A	N/A
	Under 150	3	500	480	500	N/A	N/A	N/A	N/A	N/A	N/A
Port-Orford Cedar	Over 125	1	350	N/A	N/A	350	N/A	N/A	N/A	N/A	N/A
	125 & Under	2	250	N/A	N/A	250	N/A	N/A	N/A	N/A	N/A

[13] California State Board of Equalization, Harvest Values Schedule, Effective July 1, 2015 Through December 31, 2015, BOE-401-HVS1-2H15.

Table 7. Salvage Timber (via Tractor Logging), California July-December 2015

SPECIES	PER LOG	SIZE CODE	Time Value, By Area								
			1	2	3	4	5	6	7	8	9
Ponderosa Pine	Over 300	1	160	140	60	210	240	260	250	170	100
	150-300	2	120	130	40	170	220	230	200	150	50
	Under 150	3	80	80	20	100	180	210	190	140	40
Hem/fir	N/A	N/A	150	110	N/A	140	200	160	180	160	60
Douglas-fir	Over 300	1	280	200	90	260	290	280	280	230	N/A
	150-300	2	260	190	80	250	280	260	260	220	N/A
	Under 150	3	240	140	60	230	260	230	240	210	N/A
Incense Cedar	N/A	N/A	50	80	N/A	120	210	230	200	200	60
Redwood	Over 300	1	490	500	420	N/A	N/A	N/A	N/A	N/A	N/A
	150-300	2	400	460	410	N/A	N/A	N/A	N/A	N/A	N/A
	Under 150	3	380	350	380	N/A	N/A	N/A	N/A	N/A	N/A
Port-Orford Cedar	Over 125	1	260	N/A	N/A	260	N/A	N/A	N/A	N/A	N/A
	125 & Under	2	190	N/A	N/A	190	N/A	N/A	N/A	N/A	N/A

Landfill Gas

BAC 2014 estimates that there are 53 billion cubic feet (BCF) of biomethane potentially available each year in California for RNG. This estimate is based on existing waste-in place (WIP) using a first order waste decay model (similar to US Environmental Protection Agency (EPA) LandGEM). The gross resource represents gas production from annual disposal since 1970 (1.2 billion tons WIP). The potential resource is based on an assumed 75% technical recovery factor for upgrading LFG to pipeline quality RNG.[14] This analysis assumes that RNG can be generated from all or most of California landfills, regardless of size, location and current use.

Other national biomass resource assessment studies from the NPC[15] and AGF[16] base their LFG biomethane estimates on data from EPA's Landfill Methane Outreach Program (LMOP).[17] Using LMOP data for California, ICF estimates a range for LFG RNG potential of 6.21 to 87.3 BCF per year (BCF/yr) based on varying assumptions on how much of the total LFG could be dedicated to producing RNG.

ICF's recommended range is based on the current state of high Btu landfill gas to energy projects in California. This includes biogas that is currently flared from 31 CA-LMOP candidate landfills and at least nine of the current LFG to electricity projects that could be repurposed into LFG to pipeline quality RNG given end-use

[14] UC Davis. 2014. Research Results Forum for Renewable Energy Technology and Resource Assessments, PPT from Public Workshop at the California Energy Commission Sept. 3rd 2014. http://energy.ucdavis.edu/files/09-16-2014-08_Biomass_Resource-and-Facilities-Database-Update.pdf

[15] National Petroleum Council. 2012. Topic Paper #22: Renewable Natural Gas for Transportation: An Overview of the Feedstock Capacity, Economics, and GHG Emission Reduction Benefits of RNG as a Low-Carbon Fuel. http://www.npc.org/reports/FTF_Topic_papers/22-RNG.pdf

[16] American Gas Foundation. 2011. The Potential for Renewable Gas: Biogas Derived from Biomass Feedstocks and Upgraded to Pipeline Quality. http://www.gasfoundation.org/researchstudies/agf-renewable-gas-assessment-report-110901.pdf

[17] EPA Landfill Methane Outreach Program – operational and candidate landfills. http://www.epa.gov/lmop/projects-candidates/index.html

competition, cost, and access to pipelines. These assumptions are in line with estimates from the Coalition for Renewable Natural Gas.[18] The high end of the range is representative of biogas currently flared or collected from 122 landfill sites (31 LMOP candidate landfills and 91 operational LMOP landfills).

Municipal Solid Waste

According to the UC Davis study an estimated 90 million wet tons of municipal solid waste (MSW) are generated each year in California, of which approximately half are disposed in landfills. The biomass portion of MSW includes construction and demolition wood (also known as urban wood waste), paper and paper products, grass and other yard trimmings, food waste, and other organic materials. The total biomass generated is around 35 million BDT/yr (both landfilled and diverted), or approximately 1 BDT of biomass per person per year. The UC Davis study assumes that none of the diverted portion of the material is technically available as it is being used for other purposes such as recycling, composting, and power generation. The study assumes that at least 50% of the landfilled materials would be technically available. Generally, ICF concurs with the estimates.

Wastewater Treatment Gas

UC Davis estimated the amount of available biosolids in wastewater treatment facilities based on influent waste water flow rate information provided by the EPA. UC Davis assumed a maximum biogas potential based on the flow rate and estimated biogas to be 67% recoverable. Though it is possible that the biogas produced by wastewater treatments plants could be used for other purposes, ICF generally agrees with the estimates from the UC Davis study.

US Biogas Resource Assessment

The table below includes a national-level biogas production potential, broken down by feedstock in units of trillion Btu (tBtu) for each of the studies considered. Unlike the California-focused estimates, we have not developed recommendations for the biogas production potential. This is in large part due to resource constraints i.e., it is time-consuming to conduct a state-by-state assessment given the range of studies and data sources considered. In the subsequent table, we summarize the assumptions utilized in each of the studies.

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18 The Coalition for Renewable Natural Gas. 2013. Docket Number 13-IEP-1L, Transportation Energy Scenarios and the CEC Joint IEPR-Transportation Lead Commissioner Workshop. http://www.energy.ca.gov/2013_energypolicy/documents/2013-07-31_workshop/comments/Coalition_For_Renewable_Natural_Gas_Comments_2013-08-09_TN-71825.pdf

Table 8 Overview of RNG Feedstock / Resource Assessment, United States

Feedstock	NPC[1]	AGF[2]		DOE BT[3, 4]	
		low	high	low	high
Agricultural Residue	1,300	401	1,002	327	1,872
Animal Manure	140	148	493	72	336
Energy Crops	1,500	80	200	364	6,483
Fats, Oils and Greases	n/a	n/a	n/a	n/a	n/a
Forestry and Forest Product Residue	1,100	82	206	293	569
Landfill Gas	340	182	365	n/a	n/a
MSW (food, leaves, grass)	400	69	207	148	247
MSW (lignocellulosic)				53	64
WWT Gas	60	4	13	n/a	n/a
Total Potential (tBtu)	*4,840*	*966*	*2,486*	*1,256*	*9,572*

1. The NPC and AGF reports do not differentiate MSW feedstocks.
2. The low and high values in the AGF study represent what the study refers to as *non-aggressive* and *aggressive* scenarios. The low/non-aggressive scenario assumes roughly 5-25% (depending on resource) of biomass is processed into RNG. The high/aggressive scenario assumes 15-75% (depending on resource) of biomass is processed into RNG.
3. The DOE BT study did not estimate yields of biogas. The focus of the study is on the *feedstock* rather than the *finished fuel*. ICF used conversion efficiencies from the UC Davis work to estimate the tBtu of finished fuel (in this case, biogas) based on the feedstock potential reported in the DOE BT study.
4. The low and high values from the DOE BT study represent the available feedstock assuming a price of $40/ton in 2015 and a price of $80/ton in 2030.

Feedstock	NPC 2012	AGF 2011	DOE BT Update 2011
Overall	The aim of this 2012 white paper published by the National Petroleum Council (NPC) is to provide a broad assessment of the potential for RNG as a transportation fuel in terms of feedstock capacity, cost estimates, and lifecycle GHG emission reduction. Analysis of the practical and potential inventory of feedstock sources in the U.S. suitable for RNG production	The report presents three scenarios of total biomass utilization or market penetration available on an annual basis with varying levels of feedstock utilization: a) non-aggressive; b) aggressive; and c) maximum. The report acknowledges that the aggressive scenario would require a 'concerted national effort'. The maximum scenarios assumes 100% biomass utilization and represents the upper limit for RNG production.	The 2011 Billion-Ton Update addresses a number of the 2005 report shortcomings by providing a county-by-county inventory of primary feedstocks, prices and quantities for the primary feedstocks, and a more rigorous treatment and modeling of resource sustainability. The estimates do *not* represent the total cost or the actual available tonnage to the biorefinery; rather, it provides estimates of biomass to roadside or the farmgate. [19] There are additional costs to preprocess, handle, and transport the biomass.
Agricultural Residue	Potential: The 2005 BTS was used for agricultural waste Practical: National Academy of Sciences (NAS) study on liquid transportation fuels from biomass from 2009.[20]	Includes residues from corn, wheat, soybeans, cotton, sorghum, barley, oats, rice, rye canola, beans, peas, peanuts, potatoes, safflower, sunflower, sugarcane, flaxseed. The potential, annual quantity of agricultural residues is based on the data presented in Geographic Perspective.[21]	Includes primary crop residues from the major grains—corn, wheat, sorghum, oats, and barley Also includes other residues and processing wastes: sugarcane trash and bagasse, cotton gin trash and residues, soybean hulls, rice hulls and field residues, wheat dust and chaff, and orchard and vineyard prunings Many data sets employed, including soils, slope, climate, cropping rotations, tillage (i.e., conventional, reduced, and no tillage), management practices, and residue collection technology Many factors taken into account to estimate available crop residues: soil erosion and soil organic matter constraints, physical ability of machinery to harvest residues.

[19] Roadside price is the price a buyer pays for wood chips at a roadside in the forest, at a processing mill location in the case of mill residue, or at a landfill for urban wood wastes prior to any transport and preprocessing to the end-use location.

[20] National Academies of Sciences, Liquid Transportation Fuels from Coal and Biomass: Technological Status, Costs, and Environmental Impacts, 2009.

[21] A Geographic Perspective on the Current Biomass Resource Availability in the United States, A. Milbrandt, NREL/TP-560-39181, Dec 2005.

Feedstock	NPC 2012	AGF 2011	DOE BT Update 2011
Animal Manure	Potential: Employ data from EPA's AgStar[22] program to estimate the quantity of livestock manure Practical: Data from Cuellar and Webber (2008) is to estimate the livestock manure RNG yield[23]	Include waste from dairy cows, beef cattle, hogs, sheep, poultry, and horses. Animal population data are based on state inventories that generally span the years 2006-2009; for each animal, the most recent population data was selected.[24] For horses, the most recent data acquired was based on population inventories in 1999.[25]	The 2011 BTS report estimates recoverable and available dry tons of manure based on assumptions by Kellog et al. (2000) and Gollehon et al. (2001) on the quantity of manure phosphorus excreted, recoverable, and available in excess of farm use. Production identified for beef (cattle and calves), swine, poultry (broilers and layers), and turkeys. Total production of cattle, dairy, and swine was estimated as the product of total animal units (1,000 pounds of livestock) and the percentage of inventory produced on large farms (greater than 10,000 head for cattle; 1,000 head for dairy; 5,000 head for swine). Litter available from poultry production was estimated at 70% of total poultry production (chicken broilers, chicken layers, and turkeys).

22 EPA AgSTAR, "Market Opportunities for Biogas Recovery Systems at U.S. Livestock Facilities," (November 2011): available at http://www.epa.gov/agstar/documents/biogas_recovery_systems_screenres.pdf.

23 Cuellar, AD and Webber, ME. Cow Power: the energy and emissions benefits of converting manure to biogas. Environ Res. Lett, 3, 2008.

24 Agricultural Statistics Annual, National Agricultural Statistics Service, available at http://www.nass.usda.gov/Publications/Ag_Statistics/2009/

25 Equine, USDA, National Agricultural Statistics Service, available at http://usda.mannlib.cornell.edu/usda/nass/Equine/equi1999.txt

Feedstock	NPC 2012	AGF 2011	DOE BT Update 2011
Energy Crops	Potential: Used 2005 BTS, which includes biomass grown on Conversation Reserve Program (CRP), grains for biofuels, soybeans, and perennial crops. Practical: Based on NAS 2009	Derived from NREL report; based on estimated yield of unirrigated energy crops (switchgrass and short rotation woody crops – willow and hybrid poplar). The potential, annual availability of energy crops is based on the data presented in Geographic Perspective.[26]	Two scenarios considered: baseline and high yield. Considers perennial grasses, ,woody crops, and annual energy crops Used an agricultural policy simulation model (POLYSYS) to assess the economic competitiveness of energy crop production and determine how much cropland could shift to energy crops Detailed consideration of sustainability issues for each energy crop identified
Forestry & Forest Product Residue	Potential: Based on the 2005 Billion Ton Study (BTS) Practical: Based on a NAS 2009. Included significant recovery losses and incorporated sustainability criteria such as leaving nutrient rich residues in the forest to maintain soil fertility.	Includes forest residues, mill residues, urban wood residues. The potential, annual quantity of dedicated wood residues is based on the data presented in Geographic Perspective.[27]	Estimates potential supplies of forest biomass and wood wastes under different yield and feedstock farmgate prices Primary forest biomass supply is based on estimates of recent amounts of generated logging residues and simulated silvicultural treatments on overstocked timberland, as well as pulpwood and sawlogs 72%[28] less than the 2005 BTS due to the removal of unused resources, the decline in pulpwood and sawlog markets and more explicit accounting of resource sustainability

[26] A Geographic Perspective on the Current Biomass Resource Availability in the United States, A. Milbrandt, NREL/TP-560-39181, Dec 2005.

[27] Ibid.

[28] 2005 BTS forest resource potential was 368 MDT. This is compared to the total unused forest resource available at $60/ton in 2030 (including federal lands) from the 2011 BTS report – 102 MDT.

Feedstock	NPC 2012	AGF 2011	DOE BT Update 2011
Landfill Gas	EPA Landfill Methane Outreach Program (LMOP) is used as the total resource and the fraction that is captured in gas- to-energy projects or currently flared is treated as the practical resource.	2,402 landfills in database including EPA-designated operational, potential, candidate, construction, or shutdown (2000 or later); included landfills categorized as small, large, arid, and non-arid; assumed landfill gas composition was 60% methane	n/a
MSW	Employ 2009 EPA data and assumptions regarding waste generated per person per day, US population (via AEO2012, out to 2035), and percent of waste that can be collected. Potential/total resource assumes more than 75% of total waste; practical resource assumes about 10% of waste is suitable for gasification	Only included MSW directed to landfills; did not include MSW directed to energy projects; did not consider potential volume reductions through recycling	Employ 2008 EPA data and assumptions regarding total waste generated. Differentiate between agricultural sources of MSW (food wastes, textiles, and leather) and forest sources of MSW (newsprint, paper, containers, packaging, yard trimmings, and wood)
WWT Gas	Use data from EPA[29] to estimate how much methane can be produced per person per day from waste water.	Uses database of 436 wastewater facilities with capacity of 5 MGD or greater but biogas production would only occur with 17 MGD or greater capacity	n/a

[29] Environmental Protection Agency, "Opportunities for and Benefits of Combined Heat and Power at Wastewater Treatment Facilities," U.S. Environmental Protection Agency Combined Heat and Power Partnership (October 2011): available at http://www.epa.gov/chp/documents/wwtf_opportunities.pdf.

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Appendix 2: Links to Gas Decarbonization Studies

Links to Gas Decarbonization Studies

1. Biogas World. 2018. The World's Convergence on Renewable Natural Gas: https://www.biogasworld.com/news/worlds-convergence-renewable-natural-gas/?platform=hootsuite

2. EuroGas. *Scenario Study with PRIMES*: https://gaswindandsun.eu/
Request a copy of the study by contacting Eurogas at: ks@eurogas.org

3. Gas for Climate, A Path to 2050. 2018. EcoFys, A Navigant Company. *Gas for Climate, How gas can help to achieve the Paris Agreement target in an affordable way*: https://www.gasforclimate2050.eu/files/files/Ecofys_Gas_for_Climate_Report_Study_March18.pdf

4. Biogas Italy. 2018. Presentation by Kees van der Leun of EcoFys: https://www.youtube.com/watch?v=mjIwcNCMjbU&feature=youtu.be

5. Energy Networks Association. March 2018. Gas Network Innovation Strategy: https://t.co/AukzypomSy

6. Deutsche Energie-Agentur (German Energy Agency). 2018. *dena Pilot Study 'Integrated Energy Transition': Germany needs a clear 2050 climate target*: https://www.dena.de/en/newsroom/meldungen/dena-pilot-study-integrated-energy-transition-germany-needs-a-clear-2050-climate-target/

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9. Engie. 2018. *Power-to-Gas: the solution that recovers surplus green power*: https://www.engie.com/en/news/power-to-gas/#.Wn9K3p10k_8.twitter

10. Energy Post. May 2018. *For Eastern Europe, controllable renewable power is a good alternative for new nuclear power*: http://energypost.eu/for-eastern-europe-controllable-renewable-power-is-a-good-alternative-for-new-nuclear-power/?utm_campaign=shareaholic&utm_medium=email_this&utm_source=email

11. Institute of Mechanical Engineers. May 2018. *UK 'should store excess renewable energy in hydrogen'*: https://www.imeche.org/news/news-article/uk-%27should-store-excess-renewable-energy-storage-in-hydrogen

12. Euractiv. April 2018. *Renewable power could make hydrogen cheaper than gas, study finds:* https://www.euractiv.com/section/energy/news/more-renewables-could-make-hydrogen-cheaper-than-gas-says-study/

13. Division of Information Technology, Engineering and the Environment School of Advanced Manufacturing and Mechanical Engineering. 2009. *Elaborated Whole System Approach to Achieve More Environmentally Sustainable Engineered Systems*: search.ror.unisa.edu.au/media/researcharchive/open/9915951820801831/53111918450001831

14. The Telegraph. January 2018. *Energy networks prepare to blend hydrogen into the gas grid for the first time:* https://www.telegraph.co.uk/business/2018/01/06/hydrogen/

15. Engie. *The GRHYD demonstration project* (hydrogen energy storage): https://www.engie.com/en/innovation-energy-transition/digital-control-energy-efficiency/power-to-gas/the-grhyd-demonstration-project/#.Wl0bJdHpqGY.twitter

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Appendix 3: Low-Carbon and Renewable Gas Press Release

SoCalGas, Énergir, GRDF and GRTgaz Announce Collaboration on Low-Carbon and Renewable Gas Initiatives During World Gas Conference

WASHINGTON DC, June 29, 2018 – Southern California Gas Co. (SoCalGas), today joined Énergir, a Canadian natural gas utility, along with French utilities GRDF and GRTgaz to announce a new collaboration aimed at advancing the research and development of renewable natural gas and technologies such as power-to-gas. The collaboration will focus on research and development, public policy, and outreach. SoCalGas Vice President of Customer Solutions and Strategy Sharon Tomkins made the announcement alongside Énergir Senior Vice President of Development, Communities, Corporate Affairs and Operational Safety Martin Imbleau, Laurent Théry, International and Business Development Director for GRTgaz and Christophe Wagner, International Director for GRDF, during the World Gas Conference in Washington D.C.

"Advances in natural gas technologies have helped clean our air and helped reduce emissions linked to climate change," said Sharon Tomkins, vice president of customer solutions and strategy for SoCalGas. "We are excited to collaborate with our French and Canadian counterparts to speed up the development of the next generation of innovations including renewable natural gas, solar-powered hydrogen generation, fuel cells, power-to-gas and other technologies. Together the work we're doing today will help provide reliable and affordable natural gas service to millions of families and businesses for decades to come."

"In this energy transition era, we believe renewable natural gas is a powerful tool in the fight against climate change, as well as being a significant contributor to energy self-reliance and the circular economy," said Martin Imbleau, Senior Vice President, Development, Communities, Corporate Affairs and Operational Safety for Énergir. "This collaboration with our partners will allow us to share our progress and results toward our environmental and social objectives."

"The energy transition with renewable gas needs to be advocated to become a reality worldwide," said Laurent Théry, International and Business Development Director for GRTgaz. "Our leading companies in California, Québec and France promote renewable gas in our regions and countries to reach that goal."

"The development of renewable gas is a real challenge for the energy transition and has a key role to play in the context of the low carbon strategy. The signing of this partnership agreement at the World Gas Conference reflects our shared desire to develop green gas and associated technologies and facilitate its production and injection into natural gas networks," said Christophe Wagner, International Director for GRDF. "This sharing of knowledge and experience at the international level aims to effectively meet the need for anaerobic digestion in line with the ambition we are carrying in France: 30 percent of biomethane injected into the networks in 2030."

The American, French and Canadian utilities share a common goal of advancing policies to combat climate change while providing customers with reliable and affordable energy solutions. The collaboration will build upon successes each company has earned in achieving policy initiatives and the development and advancement of new technologies. It will also serve as an opportunity to learn from research and development initiatives currently under development and corresponding regulatory frameworks.

France has adopted a renewable gas standard that calls for renewable natural gas to make up at least 30 percent of natural gas consumption by 2030. SoCalGas is supporting legislation in California that would require 5 percent of core natural gas consumption in the state to come from renewable sources by 2030. Énergir has a target to distribute 5 percent of renewable natural gas by 2025 and is working towards efforts to have a fully developed renewable natural gas marketplace by 2020.

Another key to advancing renewable energy resources is the research and development of long-term energy storage solutions. According to a 2017 Lawrence Berkley National Lab study, by 2025, between 3,300 and 7,800 gigawatt-hours of excess solar and wind energy will be wasted in California alone. SoCalGas is supporting the research and development of technologies that can harness that excess renewable electricity and convert it into energy that can be transported and stored for prolonged periods of time using existing infrastructure to deliver economic benefits to the state's ratepayers.

Last year, for example, SoCalGas announced a first of its kind project in the United States that converts hydrogen generated from excess renewable power into pipeline quality natural gas for use in homes, businesses and in transportation. If all the excess solar and wind energy detailed in the National Labs' study were converted through the biomethanation process and stored as renewable natural gas, it would provide enough renewable energy to heat 158,000 to 370,000 homes or provide renewable electricity to 80,000 to 187,000 homes.

Énergir is also working on a biomethanation project. The Canadian utility, in partnership with the city of Saint-Hyacinthe, has been delivering renewable natural gas to the pipeline system since December 2017. Saint-Hyacinthe is the first municipality in Quebec to produce energy through this process. Another endeavor Énergir and its partners G4 Insights and Greenfield Global are undertaking is the development of a pilot plant to produce renewable natural gas from Canada's abundant supply of forest biomass.

In France, GRTgaz has begun construction on an industrial-scale power-to-gas demonstration project. Jupiter 1000 will convert surplus electricity generated by wind farms on the Mediterranean coast of southern France into hydrogen and methane syngas. This will be the first project to inject hydrogen and methane syngas into France's natural gas pipeline system. When completed, Jupiter 1000 will have a total generating capacity of 1 Megawatt electric (MWe).

GRDF is working to encourage the injection of renewable natural gas into the distribution network and bring together renewable gas producers. GRDF believes green gas represents the future because it reduces CO_2 emissions and moves towards the goal of carbon neutrality. Currently, there are 50 active renewable natural gas injection sites in France with an additional 800 projects in progress. Estimates show that up to 776 GWh/yr of renewable natural gas can be injected into the French natural gas network, which is equivalent to the annual consumption of more than 63,600 households or nearly 3,000 buses. Last year, 90,000 metric tons of greenhouse gas emissions were avoided in France thanks to renewable natural gas.

As part of this collaboration, project results will be shared between the utilities. The goal is to learn from the potential successes and challenges of the projects and further build on biomethanation and power-to-gas technologies.

Over the course of the next year, representatives from each utility will continue to maintain an open dialogue around these topics, striving for continued development and distribution of renewable gas and the advancement of climate goals.

# # #

About SoCalGas

Headquartered in Los Angeles, SoCalGas® is the largest natural gas distribution utility in the United States, providing clean, safe, affordable and reliable natural gas service to 21.7 million customers in Central and Southern California. Its service territory spans 22,000 square miles from Fresno to the Mexican border, reaching more than 550 communities through 5.9 million meters and 101,000 miles of pipeline. More than 90 percent of Southern California single-family home residents use natural gas for home heat and hot water. In addition, natural gas plays a key role in providing electricity to Californians—about 60 percent of electric power generated in the state comes from gas-fired power plants.

SoCalGas has served communities in California for 150 years and is committed to being a leader in the region's clean energy future. The company is working to accelerate the use of renewable natural gas, a carbon-neutral or carbon-negative fuel created by capturing and conditioning greenhouse gas emissions from farms, landfills and wastewater treatment plants. SoCalGas is a subsidiary of Sempra Energy (NYSE: SRE), a Fortune 500 energy services holding company based in San Diego. For more information visit socalgas.com/newsroom or connect with SoCalGas on Twitter (@SoCalGas), Instagram (@SoCalGas) and Facebook.

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About Énergir

With more than $7 billion in assets, Énergir is a diversified energy company whose mission is to meet the energy needs of its 520,000 customers and the communities it serves in an increasingly sustainable way. In Québec, it is the leading natural gas distribution company and also produces, through its subsidiaries, electricity from wind power. In the United States, through its subsidiaries, the company operates in nearly fifteen states, where it produces electricity from hydraulic, wind and solar sources, in addition to being the leading electricity distributor and the sole natural gas distributor in Vermont. Énergir values energy efficiency and invests both resources and efforts in innovative energy projects such as renewable natural gas and liquefied and compressed natural gas. Through its subsidiaries, it also provides a variety of energy services. Énergir hopes to become the partner of choice for those striving toward a better energy future.

@Energir_

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About GRDF

GRDF is the leading manager of natural gas transmission networks in France, GRDF distributes natural gas each day to more than 11 million customers to ensure that they have gas when they need it, regardless of their supplier. This convenient, affordable, comfortable, and modern source of energy enables people to heat their homes, cook, and get around.

To provide this public service, GRDF builds, operates, and maintains the largest transmission network in Europe (199,781 km) and develops it in more than 9,500 municipalities while ensuring the safety of people and property, as well as high-quality distribution.

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About GRTGaz

GRTgaz is one of the European leaders of natural gas transmission and a world expert of gas transmission networks and systems. In France, GRTgaz owns and operates 32,410 km of buried pipes and 26 compression stations used to ship gas between suppliers and consumers (distributors or industrial companies directly connected to the transmission network). GRTgaz fulfils public service missions to ensure the continuity of supply to consumers and sells transmission services to users of the network. An actor of the energy transition, GRTgaz invests in innovative solutions to adapt its network and reconcile competitiveness with security of supply and preservation of the environment. www.grtgaz.com

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