DRAFT OUTLINE – FOR DISCUSSION PURPOSES ONLY

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Technical Assessment of the Beneficial Use of Flare Gas

PURPOSE

The purpose of this document is to outline a technical assessment for the beneficial use of flare gas which will examine the emission reduction benefits, the cost impacts, potential revenue, hurdles, including legal and regulatory hurdles, system problems, and incentives of using gas that would otherwise be flared. The assessment will focus on three types of sites (either actual sites or representative facilities): a large private landfill and two oil and gas sites (one remote and one urban) that engage in routine flaring because they are not currently utilizing their gas beneficially to their maximum potential. In addition, the assessment will also include a discussion on the beneficial use of gas at wastewater treatment facilities by relying on several existing detailed studies addressing the issues listed above.

The purpose of the technical assessment is to be an informative guide for facilities impacted by the requirements of Rule 1118.1 who are seeking alternatives to flaring the gas. Thus, while specific sites can be used to assist in the evaluation, the intent of the assessment is be a useful tool in understanding the broad benefits, and potential impediments, to various beneficial use alternatives for each industry sector.

BACKGROUND/INFORMATION

On January 4, 2019, the South Coast Air Quality Management District (South Coast AQMD) adopted Rule 1118.1 – Control of Emissions from Non-Refinery Flares. Rule 1118.1 applies to facilities that operate non-refinery flares located at landfills, wastewater treatment plants, oil and gas production facilities, organic liquid loading stations, and tank farms. Rule 1118.1 established requirements to reduce NOx and VOC emissions from non-refinery flares and to encourage alternatives to flaring (e.g., increase beneficial use), such as energy generation, transportation fuels, or pipeline injection. To encourage beneficial use of flare gas, and discourage routine flaring, the rule establishes an industry specific capacity threshold for existing flares. The capacity thresholds serve as a metric to identify routine flaring and applies to open flares and flares that combust digester gas, landfill gas, and gas produced from oil and gas production facilities. Flares that operate greater than the capacity threshold are required to either reduce flaring below the capacity threshold (e.g., implement beneficial use of the gas that would otherwise be flared) or replace the flare with a unit complying with the lower NOx emissions limits.

Upon adoption of the rule, the Governing Board directed staff to conduct a technology assessment of various technologies, techniques, approaches, and associated costs to beneficially use gas to reduce flaring and to report a summary of the technology assessment to the Stationary Source Committee within 24 months of rule adoption and amend the requirements for flaring produced gas if deemed appropriate.

The technical assessment will reference, but not duplicate, existing reports, or documents but can build upon existing data to create a unique and expanded Technology Assessment for the beneficial use of flare gas at the aforementioned three types of facilities within the South Coast

AQMD's jurisdiction. South Coast AQMD staff has identified and described existing reports and documents that support this technology assessment.

Technology Assessment

The technical assessment shall identify cost-effective and reliable technologies that promotes energy production or transportation fuels and conduct a wholistic cost and NOx emission impact assessment. The technology assessment will evaluate technologies most applicable to the type of flare gas generated taking into consideration existing site-specific conditions. The technology assessment will evaluate the overall cost and NOx emission impacts of alternative technologies/uses for gas that would otherwise be flared:

- Estimated emissions data profiles
    - Emission reductions achieved
    - Emissions generated
- Estimated cost and potential revenue

How do these change as you change the use of the gas/energy generated?

- Hurdles (e.g., legal or regulatory)?
- Potential systems problems (safety/reliability)?
- Incentives?

Industries Assessed

The technology assessment will be conducted for three types of sites (either actual sites or representative facilities). The preferable sites will include:

- Large private landfill,
- Remote oil and gas site, and
- Urban oil and gas site.

If the technical assessment evaluates an actual site, and not a representative or aggregate facility, facility-specific and site-specific data will be used in the assessment. If any data, or preliminary findings, are designated by the facility as confidential, or competitively sensitive information, the technical assessment shall not make public those facility-specific or site-specific data.

Beneficial Use Assessment

The technical assessment will compare the existing setting to the potential alternatives, including emission impacts, costs, and potential legal or regulatory hurdles:

- Existing Setting (amount of gas produced, current gas clean-up, energy/heat/transportation fuel used and/or generated)
    - Emissions
        - NOx emissions from existing flare
    - Costs and revenue
        - Annual Operating and Maintenance costs (O&M) for flare
        - Annual O&M for gas clean-up, if any

To streamline the analysis, the evaluation can focus on three primary potential alternatives to gas flaring – energy generation, transportation fuel, and pipeline injection. The assessment should also include any known emissions, estimated costs, potential hurdles, as well as solutions and suggestions as to pathways forward to overcome existing hurdles.

The three potential alternatives to gas flaring are discussed in further detail below to assist in illustrating the overall evaluation:

Facility Type	**Energy Generation** • Microturbines • Engines • Fuel cells • Battery Storage • Microgrids • Combined Heat & Power	**Transportation Fuel** • Compressing gas to CNG or LNG • Gas to Liquid • Gas to Hydrogen	**Pipeline Injection**
Large Landfill	✓ Emissions	✓ Emissions	✓ Emissions
Remote Oil & Gas Site	✓ Costs	✓ Costs	✓ Costs
Urban Oil & Gas Site	✓ Hurdles	✓ Hurdles	✓ Hurdles

- **Energy generation**
  - NOx emissions evaluation
    - Emissions (e.g., from the generation of heat and power)
    - Emission savings from displacing existing heating/energy (NEAT model)
  - Costs and revenue
    - Additional gas clean-up, if any
    - Energy generation equipment - total install cost (TIC) and O&M
    - Energy/heat cost savings (NEAT model)
    - Revenue from sales to the grid, if any
  - Potential legal or regulatory hurdles
    - California Public Utilities Commission (CPUC) (1 MW restriction)
    - Permitting
    - California Environmental Quality Act (CEQA)
    - Land use (local) approval – political will
    - Other regulations? (e.g., state GHG goals)
  - Other challenges
    - Infrastructure (electric grid)
    - Utilities charges + restrictions (demand charge)
    - On-site gas cleanup
    - Transmission
    - Gas quality/quantity

- **Transportation fuel**
  - Emissions evaluation
    - NOx emissions generated

        - NOx emissions offset from fuel displacement (GREET model)
    - Costs and Revenue
        - Additional gas clean-up/upgrade
        - New equipment – TIC and O&M
        - Revenue and incentives
        - Cost saving from fueling existing fleet, if any
    - Potential legal or regulatory hurdles
        - Permitting
        - California Environmental Quality Act (CEQA)
        - Land use (local) approval – political will
        - Other regulations? (e.g., state GHG goals)
    - Other challenges
        - Infrastructure (dispensing)
        - On-site gas cleanup
        - Transmission
        - Gas quality/quantity

- **Pipeline injection**
    - Emissions evaluation
        - NOx emissions generated, if any
        - Emissions offset from gas displacement (GREET model)
    - Costs and Revenue
        - Additional gas clean-up/upgrade
        - New equipment – TIC and O&M
        - Connection to pipeline
        - Revenue and incentives
    - Potential legal or regulatory hurdles and possible solutions
        - Permitting
        - California Environmental Quality Act (CEQA)
        - Land use (local) approval – political will
        - Other regulations? (e.g., state GHG goals)
    - Other challenges
        - Infrastructure (pipeline)
        - On-site gas cleanup
        - Transmission
        - Gas quality/quantity

Incentives

Lastly, the technical assessment should include a discussion of the impacts from existing incentives to beneficially use flare gas for the different industry sectors including, but not limited to:

- Funding/incentive opportunities
    - CARB's Low Carbon Fuel Standard (LCFS) for Renewable Natural Gas

    - U.S. EPA Renewable Gas Standard/Renewable Identification Numbers (RINs)
    - SoCalGas Tariff Program
    - Sales tax exemption for beneficial use projects
- Green House Gas (GHG) Incentives
    - California's Global Warming Solutions Act of 2006 (AB32)
    - Senate Bill 100 – zero carbon electricity by 2045
    - Executive Order B-55-18 Carbon Neutrality by 2045 and achieve and maintain net negative GHG emissions
    - World Bank Zero Routine Flaring by 2030 Initiative
- Others
    - Emission reduction programs
    - Rebate programs (like solar)
    - Partnerships with other entities
    - Potential future developments for energy/fuel incentives

Conclusions

The technology assessment should include recommendations on the feasibility, cost, and emissions impacts of beneficially using flare gas at the three types of facilities. The conclusion should also include any recommended actions to remove hurdles or encourage beneficial use at facilities that are currently routinely flaring and not beneficially using flare gas to the maximum potential. The technical assessment should produce a thorough guidance document that industry could reference for new ideas and incentives to handle gas more beneficially in the future.

References and Resources

The following chronological references and resources are already available to help inform the technology assessment and should be included by reference in the assessment document:

ICF, a global consulting services company, developed the following assessment for the American Gas Association (AGA) on renewable natural gas (RNG). The assessment outlines the potential for RNG to contribute meaningfully and cost-effectively to greenhouse gas (GHG) emission reduction initiatives across the country. The report serves as an update and expansion to a 2011 report published by the American Gas Foundation (AGF) entitled "The Potential for Renewable Gas: Biogas Derived from Biomass Feedstocks and Upgraded to Pipeline Quality".

- "Renewable Sources of Natural Gas: Supply and Emissions Reduction Assessment", dated December 2019 (https://www.gasfoundation.org/2019/12/18/renewable-sources-of-natural-gas/)
- "The Potential for Renewable Gas: Biogas Derived from Biomass Feedstocks and Upgraded to Pipeline Quality", dated September 2011 (https://www.gasfoundation.org/2011/10/22/the-potential-for-renewable-gas/)

Global Gas Flaring Reduction Partnership's (GGFR) developed the following document for the World Bank. GGFR's mission is to advocate for gas-flaring reduction. The document provides overviews of companies and outlines the benefits and application for each technology that can be utilized to reduce gas-flaring and potential limitations of each technology. Cost is site specific in most cases, however a range of cost per MMSCF may be listed.

- "GGFR Technology Overview – Utilization of Small-Scale Associated Gas", dated July 2019 (http://documents.worldbank.org/curated/en/469561534950044964/pdf/GGFR-Technology-Overview-Utilization-of-Small-Scale-Associated-Gas.pdf)

National Energy Technology Laboratory (NETL) prepared the following document on the life cycle of natural gas systems. It provides a complete inventory of emissions to air and water, water consumption, and land use change. At least 30 distinct scenarios include outer continental shelf and mostly land-based production of oil and gas. Each environmental scenario is detailed for emissions potential across all supply chain steps from natural gas production through natural gas distribution.

- "Life Cycle Analysis of Natural Gas Extraction and Power Generation", dated April 19, 2019 (https://www.netl.doe.gov/energy-analysis/details?id=3198)

The U.S. Environmental Protection Agency (EPA) established the Combined Heat and Power (CHP) Partnership as a voluntary program that promotes efficient CHP technologies across the United States. The Partnership works closely with energy users, the CHP industry, state and local governments, and other clean energy stakeholders to facilitate the development of new projects and to promote their environmental and economic benefits. The following webpage contains numerous documents and tools.

- https://www.epa.gov/chp/chp-documents-and-tools
- "Catalog of CHP Technologies", dated September 2017 (https://www.epa.gov/sites/production/files/2015-07/documents/catalog_of_chp_technologies.pdf)

In 2016, Senate Bill 840 (Budget Act) directed the California Council on Science and Technology (CCST) to produce an independent technical assessment analyzing regional and gas-corporation-specific issues relating to the minimum heating value and maximum siloxane specifications for biomethane addition to the common-carrier gas pipeline. The study analyzed available information that could objectively resolve the barriers to the economic development of biomethane while also considering the health, safety, and pipeline integrity concerns existing among stakeholders.

- "Biomethane in California Common Carrier Pipelines: Assessing Heating Value and Maximum Siloxane Specifications", dated June 2018 (https://ccst.us/projects/biomethane/publications.php

The California Air Resources Board contracted for the evaluation of renewable hydrogen production technologies anticipated to be available in the short, mid and long-term timeframes. The conversion technologies included thermal processes, electrolytic processes, photolytic processes, and biochemical processes. A Life Cycle Analysis using the CA-GREET Tier 2 model was performed on a subset of the production technologies for both centralized and distributed pathways, including hydrogen production via electrolysis, by biomass gasification, and by biogas reforming. An economic analysis using the H2A model was performed for these pathways. The resulting greenhouse gas emissions (gCO2e/MJ H2) and hydrogen cost ($/kg) are reported.

- "The Development of Lifecycle Data for Hydrogen Fuel Production and Delivery", dated October 12, 2017 (https://ww3.arb.ca.gov/research/apr/past/14-318.pdf)

California Air Resources Board, through the University of California Davis' Institute of Transportation Studies, identified the emergence of new interest in investment in natural gas fueling infrastructure in California raises the question regarding whether natural gas infrastructure could become stranded by the ultimate shift to lower carbon fuels or whether the natural gas infrastructure system offers synergies that could potentially facilitate speedier adoption of lower carbon fuels. Industry has advocated that overlap of key natural gas infrastructure will lower transition costs and provide consumers with an optimal mix of fuels as the state's commercial vehicle stock is replaced with alternative vehicles over time. Development of alternative fuels that have low greenhouse gas emissions and low criteria pollutant emissions, such as renewable natural gas and hydrogen, are considered a major avenue for the state of California to meet climate change and air quality goals. The report examines the precise natural gas infrastructure that is economically and technologically synergistic for both natural gas and renewable natural gas in the near-term, and alternative fuels like renewable natural gas (RNG) and hydrogen in the long term. The original design of the Low Carbon Fuel Standard (LCFS) provides time for the development of advanced, near-zero technologies. Credits from the LCFS is considered.

- Potential to Build Current Natural Gas Infrastructure to Accommodate the Future Conversion to Near-Zero Transportation Technology", dated July 2017 (https://ww2.arb.ca.gov/sites/default/files/classic//research/apr/past/14-317.pdf)

The California Air Resources Board contracted with University of California, Davis' Institute of Transportation Studies, which identified the emergence of natural gas as an abundant, inexpensive fuel in the United States and highlighted the possibility that natural gas could play a significant role in the transition to low carbon fuels. Natural gas is often cited as a "bridge" to low carbon fuels in the transportation sector. Major corporations are already investing billions of dollars to build infrastructure to feed natural gas into the U.S. trucking industry and expand the use of natural gas in fleets. In the state of California, natural gas fueling infrastructure expanded, especially in and around the ports of Los Angeles and Long Beach. The use of natural gas fueled medium and heavy-duty fleets is currently on an upswing.

Landfill gas is the largest source of Renewable Natural Gas (RNG) and is incentivized with carbon credits or other financial incentives, such as LCFS and RFS RINS, of at least $3.75 per MMBtu; a large landfill could produce 6.3 billion cubic feet per year of RNG.

- "The Feasibility of Renewable Natural Gas as a Large-Scale, Low-Carbon Substitute", dated June 2016 (https://ww2.arb.ca.gov/sites/default/files/classic//research/apr/past/13-307.pdf

The California Air Resources Board evaluated landfill emissions and energy uses through Marc Carreras-Sospedra, Michael MacKinnon and Professor Donald Dabdub from University of California, Irvine, in collaboration with Robert Williams of the California Biomass Collaborative. Biomass contributes more than 5,700 Gigawatts-hour to California's instate renewable power. Approximately 19% of in-state renewable power and 2% of full California power mix. This study assesses the air quality impacts of new and existing bioenergy capacity throughout the state, focusing on feedstocks, and advanced technologies utilizing biomass resources predominately in each region. With current technology and at the emission levels of current installations, maximum biopower production could increase NOX emissions by 10% in 2020, which would cause increases in ozone and PM concentrations in large areas of the Central Valley where ozone and PM concentrations exceed air quality standards constantly throughout the year.

- "Assessment of the Emissions and Energy Impacts of Biomass and Biogas Use in California", dated February 27, 2015 (https://ww2.arb.ca.gov/sites/default/files/classic//research/apr/past/11-307.pdf)

The National Risk Management Research Laboratory (NRMRL) is the U.S. EPA's center for investigation of technological and management approaches for preventing and reducing risks from pollution that threaten human health and the environment. The focus of NRMRL's research program is on methods and their cost-effectiveness for prevention and control of pollution to air, land, water, and subsurface resources; protection of water quality in public water systems; remediation of contaminated sites, sediments and ground water; prevention and control of indoor air pollution; and restoration of ecosystems. The document below is the NRMRL's study of Water Resources Recovery Facilities (WRRFs) with anaerobic digestion that have been harnessing biogas for heat and power since at least the 1920's. A few are approaching "energy neutrality" and some are becoming "energy positive" through a combination of energy efficiency measures and the addition of outside organic wastes.

- "Food Waste to Energy: How Six Water Resource Recovery Facilities are Boosting Biogas Production and the Bottom Line", dated September 2014 (https://archive.epa.gov/region9/organics/web/pdf/epa-600-r-14-240-food-waste-to-energy.pdf)

The California Air Resources Board, through the Department of Energy, California Energy Commission, Public Interest Energy Research Program and California Oil Producers Electric Cooperative (COPE), highlights the hurdles of the oil and gas industry in 2008 and produced a draft white paper identifying potential electrical energy opportunities through the use of stranded gas at oil production sites. The draft "White Paper" is currently not available through the California Air Resources Board website, but is available as a pdf, if requested.

- "Draft White Paper: Potential GHG Reductions from Clean Distributed Generation Technologies at Oil and Natural Gas Facilities" dated March 7, 2012 (Source: https://www.netl.doe.gov/sites/default/files/2018-05/NT15444_FinalReport.pdf)

The California Air Resources Board tested Gas Technology Institute's (GTI's) Flexible Combined Heat and Power (FlexCHP) system to evaluate delivery power and steam while holding NOx, CO, and VOC emissions below the 2007 Fossil Fuel Emissions Standard for microturbines. The system appropriately designated a FlexCHP-65, will combine a Capstone C65 microturbine, a GTI-developed supplemental Ultra-Low-NOx (ULN) burner, and a 100 Horsepower (HP) heat recovery boiler by Johnston Boiler Company.

- "Integrated CHP Using Ultra-Low-NOx Supplemental Firing", dated April 2010 (https://ww2.arb.ca.gov/sites/default/files/classic//research/apr/past/icat05-1.pdf)

The Oilfield Flare Gas Electricity Systems (OFFGASES) project was developed in response to a cooperative agreement offering by the U.S. Department of Energy (DOE) and the National Energy Technology Laboratory (NETL) under Preferred Upstream Management Projects (PUMP III). Project partners included the Interstate Oil and Gas Compact Commission (IOGCC) as lead agency working with the California Energy Commission (CEC) and the California Oil Producers Electric Cooperative (COPE).

The project was designed to demonstrate that the entire range of oilfield "stranded gases" (gas production that cannot be delivered to a commercial market because it is poor quality, or the quantity is too small to be economically sold, or there are no pipeline facilities to transport it to market) can be cost-effectively harnessed to make electricity. The utilization of existing, proven distribution generation (DG) technologies to generate electricity was field-tested successfully at four marginal well sites, selected to cover a variety of potential scenarios: high Btu, medium Btu, ultra-low Btu gas, as well as a "harsh," or high contaminant, gas.

- "Oilfield Flare Gas Electricity Systems (OFFGASES) Project", revised April 28, 2008 (https://www.osti.gov/servlets/purl/936728)

The California Air Resources Board evaluated the net emissions from the potential use of cost-effective distributed generation (DG) in California. The primary objectives of the study were to estimate the economic market potential for distributed generation, and second, to determine the resulting air emissions given that level of deployment. The ultimate goal is to provide regulators and policymakers with information that will contribute to the development of strategies and policies regarding distributed generation. Distributed generation may represent a less expensive energy delivery option, for utilities who desire to defer or avoid capital expenditures for generation, transmission and distribution infrastructure, for Electric Service Providers (ESPs) and other market participants who may employ distributed generation to provide "value added" services such as high reliability or premium power programs to customers, or for customers who may want to reduce overall energy costs, improve their electric service reliability, or increase their overall efficiency via cogeneration.

- "Air Pollution Emission Impacts Associated with Economic Market Potential of Distributed Generation in California", dated June 2000 – CARB (https://ww3.arb.ca.gov/research/apr/past/97-326.pdf)