Draft White Paper
Potential GHG Reductions from Clean Distributed Generation Technologies at Oil and Natural Gas Facilities

The purpose of this paper is to present staff's draft findings regarding the potential to use clean distributed generation (DG) technologies to generate electricity from fuel that currently is being flared in the production of oil and natural gas and to estimate the corresponding potential for emission reductions. Staff utilized existing data that Air Resources Board (ARB) has collected from oil and natural gas facilities via a survey of these facilities that was conducted in 2009. The survey was not designed to address the issue of using clean DG technologies in lieu of flaring. As such, the analysis has some limitations due to the nature of the data that was available. The assumptions used in the calculations and some of the data limitations are addressed further in the body of the paper.

Background

Gas, mainly methane and carbon dioxide (CO_2) is typically produced when oil is extracted from oil fields. This associated gas is separated from the oil and depending upon the quality and quantity of the gas, can be processed to be added to a natural gas pipeline, used as fuel for equipment at the facility, flared, or re-injected into the oil field. For the gas that is flared, staff evaluated the potential for using clean DG technologies in place of flaring thus harnessing this energy for a useful purpose (thermal or electricity) with a corresponding reduction in emissions. The evaluation also includes an estimate of the electricity potentially produced from combusting the gas that would otherwise be flared, as well as the associated impact on emissions of greenhouse gas and criteria pollutants. Additionally, natural gas is flared at some natural gas facilities. Thus, in addition to considering the potential to utilize flared gas from oil fields, staff also considered the potential for redirecting flared gas from natural gas facilities for use with clean DG technologies.

Clean DG technologies are electrical generating technologies that have very low criteria pollutant emissions[1]. Examples of clean DG technologies include microturbines, fuel cells, and a thermal oxidizer integrated with a microturbine. The estimates given in this paper are based on the best available information. Additional research including site-specific field data would be needed to refine the assumptions used in the analysis.

[1] Many of the technologies have been certified via ARB's Distributed Generation Program (sections 94200-94214 of the California Code of Regulations) to have emissions that are no greater than the emissions that would be emitted by a new combined cycle power plant equipped with Best Available Control Technology

Basis of Data Used For Analysis

This analysis is based on the results of a comprehensive ARB survey (2009) regarding oil and gas drilling and production activity during 2007[2]. The survey was completed by 325 companies representing over 1,600 facilities, and represents all activities associated with finding, producing, processing, transporting, and storing oil and natural gas.

Staff used the survey results from facilities using vapor recovery and flares. The survey requested information on the type of control device and the amount of gas that is burned in flares, thermal oxidizers, and incinerators. Based on the survey results, there are a total of 255 control devices (flares, thermal oxidizers, incinerators, carbon adsorbers, etc.) located at 178 facilities.

Staff evaluated the survey results to establish the possible sources of gas to fuel DG technologies from these facilities. Sources of gas were grouped according to facility type and control device technology for evaluation. Staff found that many of the types of facilities or control devices reported in the survey were not suitable for supplying gas to clean DG technologies. In these cases, these facilities or control devices were excluded from the DG evaluation. For example, staff evaluated the likelihood that the flared gas is either an intermittent flow or constant flow. Flared gas that is expected to be intermittent was excluded from the DG evaluation because most clean DG units require a constant flow of fuel to operate efficiently. Table 1 lists the facility types and control devices that are included in the survey results, but excluded from staff's DG evaluation and the reason for the exclusion.

[2] http://arb.ca.gov/cc/oil-gas/oil-gas.htm

Table 1
Categories Excluded From Oil and Natural Gas Clean DG Evaluation

Category Excluded From Evaluation	Reason for Exclusion
Carbon absorbers	Gas collected is typically not flared
Utility natural gas transmission stations	Flaring activity is intermittent, based on maintenance needs or emergency event; need steady flow of gas for DG
Natural gas storage facilities	Flaring is intermittent, based on maintenance needs or emergency event; need steady flow of gas for DG
Crude oil storage facilities	Gas associated with the oil is removed before reaching storage facilities; limited flaring of gas
Gas Plants	Flaring activity is intermittent, based on maintenance needs or emergency event; need steady flow of gas for DG
Off-shore facilities	Infrastructure needed to connect from platform to grid not cost effective
Flares with no reported gas usage	Assume activity would not provide steady gas flow needed for DG

Staff notes that the gas plants, as a category, flared the largest amounts of gas; however, most of the flared gas was the result of normal maintenance, which occurs infrequently, and therefore, would not be a good candidate for DG applications.

After excluding the above facilities and control devices, staff focused its evaluation on 124 combustion devices located at 88 facilities for suitability of using clean DG in lieu of flaring. The amount of gas flared by this group represents about 1/3 of the total gas flared for all sources documented to flare gas in the survey. Based on the limitations of the available data, staff views this as an approximation of the gas potentially available for DG applications. Refining the estimate would require more detailed site-specific information which is the beyond the scope of this evaluation.

Results

Using ARB Oil and Gas Field Survey results, staff determined whether there was sufficient gas flow, in terms of British thermal units (Btus) per hour, at each location identified in the survey to support at least one clean DG unit operating at 85 percent of its capacity. Staff assumed this to be the typical operating capacity for DG-sized generating equipment over the course of one year. If there was not enough gas to support the DG unit, then for the purposes of this analysis, the gas would continue to be flared. By considering the application of relatively small DG systems, such as a 65 kW microturbine, staff determined that half of the 124 flares could support that technology at 40 different facilities. However, only about a third of the flares processed enough associated gas to support one of the larger clean DG units shown in Table 2 below.

Overall, if clean DG units are used instead of the flares, about 100,000 to 200,000 megawatt-hours (MWh) of electricity could be generated from 14 to 28 megawatts (MW) of total potential generation capacity. This amount of electricity is equivalent to serving between 15,000 and 30,000 homes[3]. The lower end of the range is based on the assumption that all the gas is utilized in thermal oxidizer-microturbine hybrid devices, while the upper end of the range is based on using more efficient 400 kW fuel cell devices.

Table 2 estimates the potential emission reductions for two cases: 1) electrical generation only and 2) combined heat and power (CHP) applications using a variety of clean DG technologies. Additional reductions resulting from more efficient CHP applications are only considered for those locations that have onsite thermal needs based on responses to the survey. For CHP applications, staff assumed clean DG can only be used to displace onsite heating applications that do not require steam. For example, staff assumed the heat from a CHP application can be used in place of the heat provided by heater treaters or oil heaters.

In the table, the potential emission reductions of oxides of nitrogen (NO_x), volatile organic compounds (VOC), and greenhouse gases (GHGs) are reported for each type of clean DG system. For example, the first row reflects estimates for the potential reductions if only 65 kW microturbines are used to generate electricity and provide CHP at the sites that can support this size turbine. The lower emission reduction estimate is for electrical production only and the higher estimate includes CHP. Criteria pollutant emission reductions are based on the difference between emissions from the flaring/burning of the associated gas and the emissions from the clean DG system and the emissions from any remaining associated gas that would be flared/burned. Additional reductions would come from CHP if there are heater treaters or oil heaters at the location and electricity is displaced from the grid. GHG emission reductions are based on the difference in GHG emissions between the flare and clean DG unit, the potential for CHP application (e.g., replacement of heater treaters), and the displacement of electricity from the grid.

[3] Based on United States Energy Information Administration estimate for the electricity used by an average California home

The estimates are based on the assumption that the gas flows are constant (the survey results provided the annual amount of gas flared). If the flows vary, which is likely, then the DG units, particularly fuel cells, may need to be sized to match the lowest flow rate or provide for storage, which would lower the energy production and emission reductions shown in the table below. Additionally, site specific issues may also reduce the available amount of gas that can be used in a clean DG unit.

Table 2
Potential Emission Reductions of Different Clean DG Technologies to Utilize Gas that is Currently Flared*

Equipment	Size (kW)	Potential DG Sites / Units	NO_x (TPY[4])	VOC (TPY)	GHG (kMT/yr)[5]
Microturbine	65	40 / 282	53 – 65	10 – 12	62 – 102
Microturbine	250	17 / 60	49 – 58	<1 – 2	51 – 83
Thermal Oxidizer / microturbine	250	17 / 56	54 – 54	3 – 3	49 – 49
Fuel Cell	300	22 / 93	70 – 74	5 – 6	108 – 122
Fuel Cell	400	17 / 56	56 – 63	2 – 4	72 – 96

* Lower end of ranges based on electricity generation only, while the higher end is based on potential for CHP applications.

Staff understands that significant amounts of gas may be re-injected back into the underground reservoir from which the oil or gas came. Using this gas instead for power generation and thermal load could result in additional reductions. Finally, ARB is considering developing a measure for controlling storage tanks that are currently exempt from emission control requirements. If this measure was developed, additional gas could be available to power clean DG units that could garner additional emission reductions.

<u>Summary</u>

This paper presents staff's draft findings regarding the potential to use clean DG to generate electricity from fuel that is flared in the production of oil and natural gas and the resulting potential for emission reductions of GHG and criteria pollutants. Staff utilized existing data from an oil and natural gas facilities survey conducted in 2009. However, the survey was not designed to address the issue of using clean DG technologies in lieu of flaring. As such, the analysis had some limitations due to the nature of the data that was available. Additionally, staff did not estimate the cost or the

[4] TPY stands for standard tons per year
[5] kMT/yr stands for thousand metric tons of CO_2 equivalent emissions per year

cost effectiveness of using clean DG as costs are highly site-specific due to the nature of capturing/directing gas to DG technologies.

If clean DG units are used to combust associated gas from oil and natural gas production, the amount of gas flared is estimated to support between 14 to 28 MW of DG generating about 100,000 to 200,000 MWh per year. This is equivalent to the amount of electricity that could serve between 15,000 and 30,000 homes.

Utilizing these DG units would also result in reductions in NO_x (50 to 75 TPY), VOC (up to 12 TPY) and GHG (50 to 122 kMT/yr) emissions. These emission reductions would be equivalent to removing about 15,000 to 35,000 new cars from the road.