

BEST AVAILABLE EMISSIONS REDUCTION ASSESSMENT—PDX062

AMAZON DATA SERVICES, INC.

Prepared for

AMAZON DATA SERVICES, INC.

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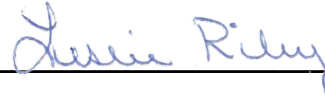
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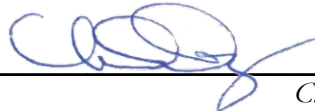
AMAZON DATA SERVICES, INC.

*The material and data in this report were prepared
under the supervision and direction of the undersigned.*

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A handwritten signature in blue ink, reading "Leslie Riley", positioned above a horizontal line.

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ACRONYMS AND ABBREVIATIONS

ACDP	Air Contaminant Discharge Permit
ADS	Amazon Data Services, Inc.
BAER	Best Available Emissions Reduction
B2H	Boardman to Hemingway
CO ₂	carbon dioxide
CO ₂ e	carbon dioxide equivalent
CPP	Climate Protection Program
CRF	capital recovery factor
CSP	concentrated solar power
DEQ	Oregon Department of Environmental Quality
EFSC	Oregon Energy Facility Siting Council
EPA	U.S. Environmental Protection Agency
GHG	greenhouse gas
GTN	Gas Transmission Northwest
HAP	hazardous air pollutant
kW	kilowatt
lb CO ₂ e/MWh	pounds CO ₂ e per MWh
MFA	Maul Foster & Alongi, Inc.
MT	metric tons
MW	megawatt
MWh	megawatt-hour
MMBtu	million British thermal units
OAR	Oregon Administrative Rule
PDX062	ADS facility located at 75300 Lewis & Clark Drive, Boardman, Oregon
PUE	Power Usage Effectiveness
PV	photovoltaics
RNG	renewable natural gas
scf	standard cubic feet
SOFC	solid oxide fuel cell
UEC	Umatilla Electric Cooperative

1 INTRODUCTION

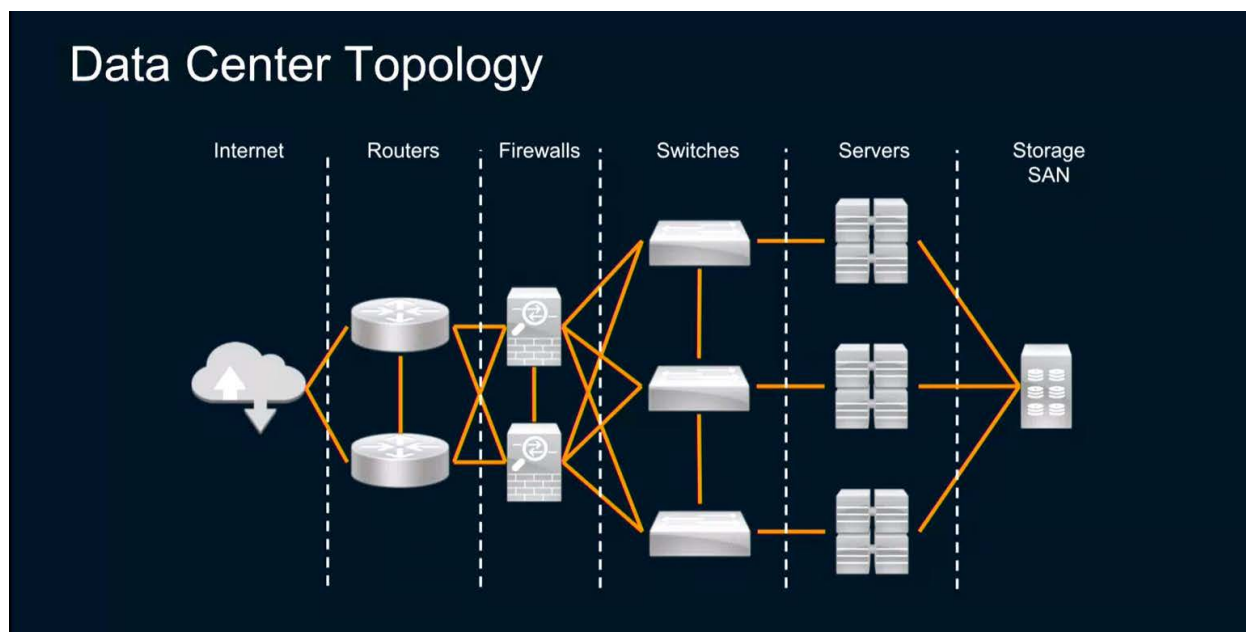
Amazon Data Services, Inc. (ADS) owns and operates the PDX062 data center located in Boardman, Oregon (PDX062 or “site”) under Standard Air Contaminant Discharge Permit (ACDP) No. 25-0029-ST-01 issued April 20, 2018. PDX062 is considered a synthetic minor source under the Title V program. ADS has an ACDP modification application for this site currently under review, as the result of filing a Notice of Construction package for this facility in September of 2021. The ACDP modification application requests approval to install solid oxide fuel cells (SOFC) as a continuous power source with a capacity of approximately 24 megawatts (MW) per hour and to make other minor permit updates associated with the request. The ACDP modification application includes a full project description and is included in Appendix A.

ADS designs its data centers to provide the efficient, resilient service their customers expect while minimizing the data center’s environmental footprint. ADS facilities are 3.6 times more energy efficient than the median of U.S. enterprise data centers surveyed and up to five times more energy efficient than the average in Europe (Amazon, 2021). This site houses cloud computer systems and associated components such as telecommunications and data storage systems. Equipment includes security systems, data communications equipment, and environmental controls. Electrical power systems are designed to be fully redundant so that in the event of a disruption, diesel-fired emergency generators provide back-up power for uninterrupted continuous datacenter operations. The PDX062 site air permit currently authorizes ADS to operate 107 emergency generators and two fire pumps, for a total capacity of approximately 261.5 megawatts (MW). Drawing G1.1 presents a site plan including the site boundary. Figure 1-1 presents the site boundaries of ADS-owned properties within five miles of PDX062. Drawing G1.1 and Figure 1-1 are in Appendix B.

This site houses networked computer servers that store, process, and distribute large amounts of data. Energy is used to power both the IT hardware (e.g., servers, drives and network devices) and the supporting infrastructure such as HVAC systems and cooling equipment. Electricity is distributed from the electrical substation transformers to the uninterruptable power supply system. The uninterruptible power supply system is used to provide backup power to keep the equipment running in case of a power outage. Power distribution units distribute power to the various equipment in the data center, while also providing monitoring capabilities to ensure efficient power utilization. The servers use the majority of the electricity at the site. The amount of electricity required to power servers depends on their size, configuration, and workload. Size and workload also determine the electricity usage by the storage devices and network equipment, such as switches and routers.

Figure 1-2, below, presents the channels used to connect the various nodes, servers, and devices used to create network connections by the data center.

Figure 1-2. Data Center Topology



ADS requires a continuous electrical supply to operate the site. ADS works closely with local and regional utilities, including the Umatilla Electric Cooperative (UEC), to secure this supply. Despite these efforts, at the time of this application ADS is limited to 135 MW of electricity at PDX062, which is significantly less than nameplate capacity at the site. The ability to serve the nameplate capacity for ADS needs in the region is several years away and will require significant infrastructure upgrades. ADS proposes to temporarily offset 24 MW, a portion of this shortfall, by onsite fuel cell generation while transmission infrastructure improvements in the region are advanced. The proposed fuel cell generation will only meet a small portion of ADS's customer needs at this location (less than 10 percent of the overall site needs). An example of the type of system wide upgrade in the region and that could provide additional load serving capacity to alleviate the type of constraint experienced at PDX062 is the construction of a new 290-mile, 500-kilovolt transmission line from southwest Idaho to Boardman, Oregon (referred to as the Boardman to Hemingway [B2H] Transmission Line). The B2H Transmission Line is currently before the Oregon Energy Facility Siting Council (EFSC). The B2H project was issued a site certificate in late 2022, but that certificate is currently undergoing appeal before the Oregon Supreme Court (the appeal was filed in December 2022). The project developer also sought amendments to the site certificate from EFSC in late December 2022 that will alter the route. After several years of planning and development, it is not anticipated that construction on the B2H Transmission Line will begin until approximately 2026. Construction completion is estimated to take approximately four years, absent any further delays or extensions. This is one example intended to illustrate the complexities and timeline associated with the type of infrastructure development that is needed in the region. Additionally, completion of the B2H Transmission Line may not fully address regional infrastructure needs and will need to be coupled by reliable energy generation and other infrastructure improvements.

Without additional on-site power generation, PDX062 cannot efficiently use existing equipment to serve planned ADS customer needs. On-site power generation beyond the 135 MW currently being provided by local and regional utilities is necessary to maintain the operations authorized by the existing permit and is not intended to reduce or eliminate the amount of electricity currently supplied by UEC. This request should not be viewed as an analysis of which alternatives can be deployed instead of the fuel cells but as an analysis of one of many solutions that will help solve an infrastructure supply gap that currently exists. ADS is in the process of exploring other power sources in addition to this project, such as procuring additional renewable resources, working with local and regional utilities to build new transmission and distribution infrastructure, and implementing special protection schemes such as Remedial Action Schemes that more effectively uses existing capacity, but they are not readily deployable or feasible on the timeline that the technologies explored in this document are possible and, therefore, they are not the subject of this Best Available Emission Reduction (BAER) determination. ADS facilities have several requirements that limit the selection of viable on-site power generation solutions, including the following:

- The site requires a supply of power generation on site to address the energy gap that currently exists due to insufficient transmission infrastructure to serve all of ADS's requested power needs.
- The site requires 100 percent uptime power availability.
- The site requires the ability to service the power generation while still producing power.
- The generation solution must meet noise ordinance requirements of the site.
- The site has approximately 98 acres of land for siting a solution, over 70 percent of which will be developed for facility operations.
- The Local Distribution Company will not provide natural gas to the site for use in a combustion or oxidation process.¹

The following BAER analysis has been conducted with the understanding that any potential on-site power solution located at PDX062 that causes the site to exceed 25,000 metric tons (MT) of greenhouse gases (GHGs) will cause the site to be a "covered entity" under the Climate Protection Program (CPP), as that term is defined in Oregon Administrative Rules (OAR) 340-271-0110.

¹ ADS does not believe that the DEQ has authority under the Climate Protection Program (CPP) to require the purchase of natural gas from a particular source or to incorporate a condition requiring the purchase of natural gas from a particular source in a BAER Order. Notwithstanding, ADS notes that prior to pursuing natural gas from Gas Transmission Northwest (GTN), it did initially attempt to procure natural gas from the LDC, Cascade Natural Gas. Correspondence from the LDC confirming it declined to serve the proposed project if the project's emissions are subject to the CPP cap is included in Appendix C. Several subsequent requests for additional clarification or documentation on this point have been unsuccessful.

2 BAER ANALYSIS METHOD

2.1 Need for BAER Analysis

A BAER analysis is required under the CPP to determine the best available emissions reductions that can be implemented for a source of GHG emissions where such emissions occur at a “covered stationary source” (OAR 340-271-0110[5]). PDX062 is an existing source. Proposed anthropogenic GHG process emissions from the oxidation of natural gas will exceed 25,000 MT carbon dioxide equivalent (CO₂e) per year. The natural gas employed at PDX062 will not be delivered by a local distribution company, so the resulting emissions are not exempted from OAR 340-271-0110(5)(b)(B). Therefore, this BAER analysis is being submitted in response to the Oregon Department of Environmental Quality’s (DEQ) request that BAER be addressed as part of the permitting process consistent with OAR 340-271-0310(1)(a).

This BAER analysis evaluates technically feasible alternative sources of energy and/or emission controls that are the least carbon intensive (i.e., result in the greatest reduction of emissions), while considering economic feasibility and environmental/health and energy impacts. This BAER analysis is potentially unique in that it evaluates alternatives for addressing a regional need; the provision of approximately 24 MW of electricity through on-site generation is necessary to address the shortfall that will exist until the ancillary and supporting facilities needed to deliver electricity in quantities equivalent to ADS’ requests are not constrained due to transmission and distribution infrastructure.

2.2 BAER Assessment Requirements

In accordance with OAR 340-271-0310(2), a BAER assessment must include the following:

1. A description of the covered stationary source’s production processes and a flow chart of each process.
2. Identification of all fuels, processes, equipment, and operations that contribute to the covered stationary source’s covered emissions, including:
 - a. Estimates of anticipated annual average covered emissions. Emissions must be identified in MT CO₂e, following methodologies identified in OAR 340-215.
 - b. Estimates of current annual average type and quantity of all fuels used by the covered stationary source and anticipated annual average fuel usage for new sources.
3. Identification and description of all available fuels, processes, equipment, technology, systems, actions, and other strategies, methods, and techniques for reducing covered emissions described in OAR 340-271-0110(5)(b). According to OAR 340-271-0310(2)(c), strategies considered must include but are not limited to the strategies used by other sources in this state or in other jurisdictions that produce goods of comparable type, quantity, and quality.

4. An assessment of each of the following for each strategy identified in OAR 340-271-0310(2)(c):
 - a. An estimate of annual average covered emissions reductions achieved if the strategy were implemented compared to the emissions estimated in OAR 340-271-0310(2)(b)(A).
 - b. Environmental and health impacts, both positive and negative, if the strategy were implemented, including any impacts on air contaminants that are not GHGs and impacts to nearby communities.
 - c. Energy impacts if the strategy were implemented, including whether and how the strategy would change energy consumption at the covered stationary source, including impacts related to any fuel use that results in anthropogenic GHG emissions. Any energy-related costs must be included in the economic impacts assessment in paragraph (D), not in the energy impacts assessment.
 - d. Economic impacts if the strategy were implemented, including operating costs and the costs of changing existing processes or equipment or adding to existing processes and equipment. Any energy-related costs must be included in the economic impacts assessment, not in the energy impacts assessment in paragraph (C). The economic impacts assessment must include both costs and cost savings (benefits).
 - e. An estimate of the time needed to fully implement the strategy at the covered stationary source.
 - f. A list of the information, resources, and documents used to support development of the BAER assessment, including, if available, links to web pages that provide public access to supporting documents.

2.3 BAER Evaluation Method

The selection of BAER technology factors into “*whether a strategy under consideration by DEQ to reduce covered emissions is achievable, technically feasible, commercially available, and cost-effective*” (OAR 340-271-0320) by reference to strategies achieved at other sources “*that produce goods of comparable type, quantity and quality*” (OAR 340-271-0310(2)(c)). These criteria and the ultimate objective of a BAER analysis, to reduce GHGs to the extent reasonably feasible, are best achieved by a top-down analysis approach, which does not limit the possibilities for analysis, but provides a framework to objectively evaluate the solutions, or combination of solutions, in order of lowest to highest carbon intensity for the energy need.

Following a top-down evaluation type of approach to arrive at a BAER determination, the basic five-step process has been used with some modification:

- Step 1—Identification of Alternative Power Sources/Emission Reduction Options.
- Step 2—Elimination of Technically Infeasible Options.
- Step 3—Ranking of Remaining Alternative Power Sources/Emission Reduction Options by Effectiveness (Least Carbon Intensive to Most Carbon Intensive).
- Step 4—Evaluation of the Most Effective Power Source/Emission Reduction Option.

- Step 5—Select BAER.

2.3.1 Step 1—Identify Alternative Power Source/Emission Reduction Options

A list of alternative power sources/GHG emission reduction options is created as the first step in the BAER analysis. Options identified include those known to have been used for similar sources; those that are commercially available, emerging, and applicable; those that may be applied internationally (to the extent that they can be identified); and those that may be applied to a different source type but would represent transferable technology. To identify power source/GHG emission reduction options, internet searches for installed or permitted options and vendor inquiries are conducted.

2.3.2 Step 2—Eliminate Technically Infeasible Options

Step 2 in the BAER analysis eliminates technically infeasible alternative power source/GHG emission reduction options. Issues with siting, availability of fuel or materials, equipment size, or the impact of other control technologies that must be used in series with a given option are all considered. Only commercially available options are considered (OAR 340-271-0320(2)(h)).

2.3.3 Step 3—Ranking of Remaining Alternative Power Sources/Emission Reduction Options by Effectiveness

Step 3 in the BAER analysis ranks technically feasible and commercially available power source/GHG emission reduction options by their respective emission rates from lowest GHG emission rate to highest.

2.3.4 Step 4—Evaluation of the Most Effective Power Source/Emission Reduction Option

After ranking the available and technically feasible control technology options, the energy, environmental and health, and economic impacts are assessed for the lowest-emitting option. If the lowest-emitting option is not viable from an energy, environmental and health impact, and/or economic perspective, then the next most effective option is assessed.

2.3.4.1 Energy Impacts

Energy impacts can include electricity and/or supplemental fuel used by a power source or emission control option. Electricity use can be substantial for large projects if the power source or control device uses large fans, pumps, or motors. Similarly, sources may use significant amounts of fossil fuels, which also can lead to economic impacts as well as climate change impacts. If it is shown that the emission reduction benefit that will be achieved is outweighed by an unacceptable energy impact, the technology is not considered an acceptable solution.

2.3.4.2 Environmental and Health Impacts

Some power source and emission reduction options have environmental impacts such as increased emissions of air pollutants, increased or changed solid or hazardous waste generation, and noise impacts. As an example, the U.S. Environmental Protection Agency (EPA) Environmental Appeals Board has upheld EPA's determination that the use of water can be considered an adverse impact on the environment that would merit forgoing further consideration of a particular control technology (*Columbia Gulf Transmission Co.*, PSD Appeal No. 88-11). If it is demonstrated that the emission reduction benefit that will be achieved is outweighed by an unacceptable environmental impact, the technology is not considered an acceptable solution.

In addition to environmental impacts, a BAER analysis must consider health impacts. Some power source and emission reduction options may have health impacts associated with increased criteria, hazardous, or toxic air pollutants. Noise may also be considered a health impact. If unacceptable health impacts are identified, the power source/GHG emission reduction technology is not considered an acceptable solution.

2.3.4.3 Economic Impact

The economic analysis of a power source/GHG emission reduction option is based on the cost-effectiveness, calculated by dividing the total net annualized cost of a given control technology by the tons of pollutant avoided or removed per year by that option.

The total net annualized cost has two main components:

- Total capital investment (annualized)
- Total annual costs

The total capital investment includes the direct cost of the control technology equipment and appropriate auxiliaries as well as the direct and indirect costs to install the equipment. Direct installation costs include the costs for foundations, erection, electrical, piping, insulation, painting, site preparation, and buildings. Indirect installation costs include engineering and supervision, construction expenses, startup costs, and contingencies.

Since the total capital investment is a lump sum value, it must be annualized to be included in the total net annualized cost. This is done using a capital recovery factor (CRF), which accounts for the cost of liquid assets and the amortization of the lump sum cost. The CRF is calculated using an assumed interest rate and an assumed equipment life. For this analysis, the appropriate equipment life is the estimated duration of the period between current operation of the site and completion of such infrastructure upgrades as the B2H Transmission Line and the ancillary and supporting facilities needed to deliver electricity to the site. The CRF is then multiplied by the total capital investment to produce a total annualized capital investment.

The annual costs include those that occur every year of operation. These include operation and maintenance labor, replacement parts, overhead, raw materials, and utility consumption. The total net annualized cost is the sum of the total annualized capital investment and the total annual cost.

2.3.5 Step 5—Select BAER

The power source/GHG emission reduction technology resulting in the lowest emission level that is technically feasible, commercially available, cost-effective, and that does not result in unacceptable energy or environmental/health consequences is selected as BAER for the project.

3 BAER DETERMINATION FOR GHGS

3.1 Step 1—Identify Power Source/Emission Reduction Options

A BAER analysis is done to consider all technology and control options that would result in the fewest GHG emissions. An online review of power generation options currently available in the marketplace was conducted. Each source type requires a separate BAER analysis based on its operations, fuels, and emissions. The site considered the following technologies for power generation:

- Additional on-site energy conservation
- Local power grid
- Solar energy
- Wind energy
- Bloom Energy SOFC technology
- Bloom Energy SOFC and carbon dioxide (CO₂) capture
- Bloom Energy SOFC using renewable natural gas (RNG) as feedstock
- Bloom Energy SOFC with RNG attributes
- Bloom Energy SOFC using hydrogen as feedstock
- Fossil fuel-fired generators
- Combined cycle power plant

Each of these technologies is discussed below.

3.2 Step 2—Eliminate Technically Infeasible Options

Step 2 evaluates the technical feasibility of the power-generation technologies identified in Step 1.

3.2.1 Additional On-site Energy Conservation

ADS is committed to approaching sustainability with bold thinking and relentless innovation. In furtherance of this commitment, ADS expended significant resources to ensure that the equipment used at PDX062 reflects the state of the art for data centers of its vintage. Electricity is a large operating expense and, as is explained elsewhere in this analysis, it is currently in short supply in this region due to transmission constraints. According to the Bonneville Power Administration, the Boardman area is at the limit of existing 115 kilovolt and 230 kilovolt sources and there are over 2,500 MW of renewable energy generation in the queue waiting to come online (BPA 2022).

However, until the transmission bottleneck is resolved, and those renewable energy resources become available to use, there is an electricity shortfall that drives ADS's need to conserve. In short, economic prudence and lack of resources, as well as ADS's unwavering commitment to sustainability, drive the company to conserve electricity.

Amazon has made a Climate Pledge commitment to reach net zero carbon by 2040 and ADS must reduce a broad category of emissions from sources resulting from business operations. This also includes indirect carbon emissions from things such as the construction of data centers and the manufacturing of hardware. ADS facilities are 3.6 times more energy efficient than the median of U.S. enterprise data centers surveyed and up to five times more energy efficient than the average in Europe (Amazon, 2021). ADS follows the latest industry standards for energy utilization and effectiveness, including The Green Grid, the International ISO/IEC 30134-2, and the ASHRAE 90.4 energy standard for data centers. ADS uses Power Usage Effectiveness (PUE) as the industry-preferred metric for measuring energy efficiency in data centers, for guiding new facility design and monitoring existing facility operations. Consistent PUE monitoring and evaluation allows ADS to measure success of its data center designs, Total Cost of Ownership, retrofit projects, and day-to-day operations with respect to overall power usage.

Customers migrate workloads from on-premises data centers to ADS for many reasons, including increased agility and innovation, access to global infrastructure, and cost savings. According to 451 Research, moving on-premises workloads to ADS can lower the workload carbon footprint by 88 percent for the median surveyed US enterprise data centers and 72 percent on average for the top 10 percent most efficient enterprises surveyed (Amazon, 2019). This means that migrating the average 1-MW enterprise data center with 30 percent utilization to ADS, a customer could reduce their carbon emissions by 400 to 1,000 MT per year. In addition to the efficiency of internal operations, Amazon leads the Amazon Sustainability Data Initiative seeking to accelerate sustainability research and innovation by minimizing the cost and time required to acquire and analyze large sustainability datasets (ASDI, 2023).

PUE is determined by dividing the total amount of power entering a data center by the power used to run the equipment within it. PUE is expressed as a ratio, with overall efficiency improving as the quotient decreases toward 1.0. PUE data for PDX062 from February 2022 until May 2023 is as follows:

- PDX062 PUE mean: 1.1
- PDX062 PUE min: 1.066
- PDX062 PUE max: 1.251
- PDX062 PUE median: 1.091

New data center builds using advanced cooling technology can achieve PUEs of 1.3 or below. As these data illustrate, ADS data centers achieve PUEs that reflect very high levels of energy efficiency. This is reflective of ADS's commitment to using energy efficient cooling.

ADS maximizes the use of free-air cooling systems that cool servers with outside air without using any water. During peak summer temperatures the site utilizes direct evaporative cooling, which uses water to cool the air that removes heat from the servers. The units are optimized to use minimal water which increases energy efficiency. ADS has installed the latest and most energy efficient approved technology for its data center at this location. Additional information about Amazon's

energy efficiency at its data centers can be found at the following link: <https://sustainability.aboutamazon.com/environment/the-cloud>.

All reasonable energy conservation measures have been employed, including measures such as energy efficient lighting. Telecommunications and data storage equipment is intrinsic to the product that ADS produces; the storage, management and dissemination of electronic data. No additional change in equipment is possible without impacting the quality of ADS's product. Therefore, additional on-site energy conservation is eliminated as technically infeasible.

3.2.2 Local Power Grid

The local supply grids in the United States are powered using a variety of sources, including natural gas, nuclear power, coal, and oil, and smaller contributions from renewable resources. Most electricity in the United States is generated at centralized power plants. Newly generated electricity travels through a series of interconnected high-voltage transmission lines. Substations reduce high-voltage power to a lower voltage, sending the lower-voltage electricity to customers through a network of distribution lines. The availability of electricity in any particular area is ultimately dictated by the proximity of generation and the availability of transmission.

The UEC provides electrical service to PDX062. At the time of submission, UEC is only able to deliver up to 135 MW of electricity to the site. As noted above, over 2,500 MW of renewable energy is in the queue awaiting the expansion of transmission services so that it can be delivered to local utilities. Once transmission constraints have been alleviated, those renewable energy sources need to be procured and contracted to be delivered to ADS. Each resource must have a completed interconnection study and subsequent agreements with local and regional utilities that would enable the delivery to ADS.

Amazon and UEC have developed a first of its kind relationship that enables Amazon to take on the responsibility of selecting the energy supply that powers its data center operations. This is inclusive of many new renewable energy resources. Amazon has invested over \$15 billion in the state economy since 2011, recycles up to 96 percent of ADS cooling water to provide millions of gallons of water to local farmers each year, and is now able to directly invest in renewable energy across the Pacific Northwest to help power ADS operations in Oregon. This collaboration with ADS and UEC will be critical to helping ADS meet their renewable energy goals for powering their facilities.

ADS is doing everything it can to procure and supply renewable power from the local power grid, but the previously discussed regional transmission constraints deem this alternative technically infeasible. These regional transmission constraints are the driver for the approximately 24 MW of onsite power generation at PDX062 proposed in this BAER analysis. Because ADS is proposing onsite power generation, additional electricity supply through the local power grid is eliminated from this analysis as technically infeasible.

3.2.3 Solar Energy

There are two main types of large-scale solar energy plants:

- Concentrated solar power (CSP)
- Solar photovoltaics (PV)

3.2.3.1 CSP

CSP plants use mirrors to concentrate the sun's thermal energy to drive traditional steam turbines or engines that create energy. A CSP plant can generate electricity via a steam turbine for immediate power, or it can incorporate thermal energy storage, where the sun's heat energy is collected and stored in a medium such as molten salt. This enables the plant to continue to generate electricity in periods of low sunlight. CSP plants, like all thermal electric plants, require a substantial amount of water for cooling. Water use depends on the plant design, the plant location, and the type of cooling system.

There are three major types of CSP technology systems: parabolic trough systems, compact linear Fresnel reflectors, and power towers. Parabolic trough systems use curved mirrors to focus the sun's energy on a receiver tube that runs down the center of a trough. In the receiver tube, a high-temperature heat transfer fluid (such as a synthetic oil) absorbs the sun's energy, reaching temperatures of 750 degrees Fahrenheit or higher, and passes through a heat exchanger to heat water and produce steam. The steam drives a conventional steam turbine power system to generate electricity.

Compact linear Fresnel reflector systems are similar to parabolic trough systems, but with long, parallel rows of lower-cost, flat mirrors. These modular reflectors focus thermal energy on elevated receivers, which consist of a system of tubes through which water flows. The concentrated sunlight boils the water, generating high-pressure steam for direct use in power generation and industrial steam applications.

Power tower systems use a central receiver system, which allows for higher operating temperatures and greater efficiencies. Computer-controlled mirrors called heliostats track the sun along two axes and focus solar energy on a receiver at the top of a high tower. The focused energy is used to heat a transfer fluid to produce steam and run a central power generator.

3.2.3.2 Solar PV

Solar panels create energy from sunlight through the solar PV process. Unlike CSP plants, PV plants do not generate large amounts of heat from thermal energy, so little to no water is required.

Sunlight is composed of photons, which are small bundles of electromagnetic radiation that can be absorbed by a PV cell. PV cells absorb incoming photons to provide energy and generate an electrical current through what is known as the photovoltaic effect. The movement of electrons, each carrying a negative charge, toward the front surface of the PV cell creates an imbalance of electrical charge between the cell's front and back surfaces. This imbalance, in turn, creates a voltage potential like the negative and positive terminals of a battery. Electrical conductors on the cell absorb the electrons. When the conductors are connected in an electrical circuit to an external load, such as a battery, electricity flows in the circuit.

3.2.3.3 CSP and PV Siting and Reliability

According to the Great Plains Institute, a conservative estimate for the footprint of solar development is 10 acres of land to produce one MW of electricity (Wyatt and Kristian 2021). However, conditions at the generation site will affect this estimate. Power generation potential will

vary depending on the intensity of the sun's energy. For example, The National Renewable Energy Laboratory lists annual average daily total solar resource for the U.S. Southwest as greater than 5.75 kilowatt-hours per square meter per day, while most of the Pacific Northwest is listed as less than 4.00 kilowatt-hours per square meter per day (NREL 2018). Although it is likely that land requirements in the Pacific Northwest are larger than 10 acres/MW, using this estimate, a 24-MW solar farm requires, at a minimum, approximately 240 acres, which is more land than is available at the PDX062 site. As noted at the outset of this analysis, a majority of the 98-acre site is dedicated to equipment critical to the site's intended purpose and cannot be repurposed to solar power generation. Additionally, ingress and egress and emergency response considerations dictate that significant additional portions of the site could not be used for this purpose.

Other factors besides the absence of available real estate make solar infeasible. Fluctuations in power supply can lead to lengthy periods of downtime. The site needs a continuous, reliable power supply; however, solar energy is not always produced when energy is needed. Solar energy production can be affected by season, time of day, clouds, dust, haze, or obstructions such as shadows, rain, snow, and dirt. Battery storage and backup generators would be required to supplement power provided by solar energy for the power supply to be available at all hours.

Lithium-ion batteries are one such storage technology. Although using energy storage is never 100 percent efficient, as some energy is always lost in converting energy and retrieving it, storage allows the flexible use of energy post-generation. Storage can increase system efficiency and resilience, and it can improve power quality by matching supply and demand. However, large-scale battery storage requires additional infrastructure and available real estate, which is not readily available. The results of overheating can be disastrous in battery farms, where batteries reside in fairly close proximity to one another. Integrated cooling systems are necessary to prevent battery failure, and in some cases, ignition.

Finally, planning, permitting, and constructing a solar farm would take several years to complete. Based on the timeline for a solar PV energy generation facility in Lake County, Oregon, permitting alone may take up to three to four years, with another four years for construction. More importantly, however, an off-site solar farm would have no utility without the construction of the transmission infrastructure discussed above. Because transmission is the constraint, the only viable means to additional power at this location are on-site solutions. Therefore, construction of a solar farm is not a viable option. It will not be commercially available within the time frame needed and even if it were, a lack of transmission infrastructure remains a barrier to delivering it to the utility.

3.2.3.4 Rooftop Solar

The PDX062 campus currently remains under construction. The site plan (illustration included in Appendix B) for the campus includes four large buildings, each representing a single data center. Each building is approximately 220 feet wide by 1,000 feet long but as can be visualized from a satellite image of a nearby campus in the area (Figure 1-1 in Appendix B), not all of the roof space can be used for a rooftop solar installation. ADS estimated that approximately 130,000 square feet of roof space on each building is available, given the layout of HVAC equipment and other elements necessary to support the operation of the data center. Estimates of a layout similar to this would result in approximately 5,000 modules or 2,025 kilowatt peak DC with a 10 degree tilt. A 1.5 DC/AC ratio with inverter capacity was considered for the analysis based on typical industry standards. It is assumed that additional panels could be installed above the parking stalls and along

certain walls, depending on location and orientation, that would yield approximately 100 kW of additional capacity per building. ADS used the IBC Solar calculator for estimates of PV Capacity based on roof area (IBC, 2023).

Furthermore, ADS used the NREL PVWatts calculator (NREL, 2022) to compare weather specifics in conjunction with estimates on the size of the system to produce a potential system output range. The calculator estimated that the system output for a project of this type in Boardman, Oregon with approximately 2.125-kilowatt peak DC per building would yield approximately 2,686,399 kWh per year. On an average basis over the entire year, this is equivalent to approximately 306 kW. If a similar system was used on all four of the buildings on the PDX062 site, an average of 1.2 MWs could be used to offset the energy needs on this site as a result of the installation of a rooftop PV system.

ADS requested cost estimates for rooftop PV installations. Design, permitting, all system components up to house switchboard, installation, and commissioning were included in the scope. The estimates provided by respondents exclude additional costs that may be required like fireproof barriers between the PV system and roof, lightning protection, and any modifications to the data center electrical system. The total estimated costs for this area of Oregon can be estimated at \$2.00 per watt of DC installed capacity. The installation costs associated with carports, walls, and other areas can be as much as double this cost. In addition, the provision of operation and maintenance costs for the system can be estimated at \$11/kw/year. According to ADS, the estimated costs per building are approximately \$4.3 million and if this type of system were installed on all four buildings on site the total cost would be approximately \$17 million.

Off-site solar electricity generation is not a viable option for the site as discussed above. Moreover, the addition of rooftop solar would not obviate the need for the approximately 24 MW fuel cell installation at this location. Even with the addition of the 24 MW fuel cell installation and any additional small amount of capacity that might be generated from a rooftop solar project, there is insufficient infrastructure in place to deliver additional electricity to the site, and the entire focus of the project subject to this BAER analysis is how to provide electricity to the site during the interim period before the required transmission capacity exists.

In accordance with OAR 340-271-0310, strategies considered in a BAER assessment must produce goods of comparable type, quantity, and quality. While rooftop solar is technically feasible, it would need to be coupled with storage capabilities and would not produce enough energy to reduce the need for the 24 MW power generation provided by the fuel cells. The output from a solar option would not produce goods of comparable quality or quantity as other potential sources of energy reviewed in this report. Lack of the same transmission infrastructure that would deliver power from the grid further render off-site solar an infeasible solution at this time. Therefore, solar energy is considered a technically feasible option, but the incremental energy produced does not reduce the portion of the approximately 24 MW of power generation from the proposed fuel cell project to the PDX062 site. However, Section 3.4.2 includes an analysis of the energy, environmental, and economic impacts of using rooftop solar in conjunction with the Bloom Energy SOFC to generate a portion of the energy requirements at the site.

3.2.4 Wind Energy

Wind turbines use wind to generate electricity by turning propeller-like blades of a turbine around a rotor, which spins a generator creating electricity. When wind flows across the blade, the air pressure across the two sides of the blade creates both lift and drag. The force of the lift is stronger than the drag, and this causes the rotor to spin. The rotor connects to the generator, either directly or through a shaft and a series of gears that speed up the rotation and allow for a physically smaller generator. The translation of aerodynamic force to rotation of a generator creates electricity.

Differences in vegetation, terrain, and water bodies cause wind flows and speeds to vary from one location to the next, making some locations better suited for wind energy than others. Wind speeds and frequency are higher near the coast and offshore than in inland areas.

There are two main types of wind turbines: horizontal-axis and vertical-axis. Horizontal-axis wind turbines typically have three blades and operate “upwind,” with the turbine pivoting at the top of the tower, so the blades face into the wind. Vertical-axis turbines come in several different varieties, including the eggbeater-style Darrieus model. The vertical-axis turbines are omnidirectional and do not have to be adjusted to point into the wind.

Maul Foster and Alongi, Inc. (MFA) attempted to contact four wind developers to get additional information about the feasibility of wind power for additional on-site generation at PDX062. Ultimately, only two companies were responsive and further information about their assessment of feasibility and cost is provided, where relevant, below.

3.2.4.1 Siting and Reliability

Wind power plants have substantial land-use requirements. Based on data for 172 projects, the National Renewable Energy Laboratory calculated the average value for total-area data for projects representing about 25 GW of proposed or installed capacity (Denholm et al. 2009). The average value for the total project area was about 34.5 ± 22.4 hectares per MW, or 85 acres per MW. MFA contacted Vestas North America to inquire about their technology. According to Steelhead, the utility scale power generation development arm of Vestas, the rule of thumb for wind generation is 75 acres per MW, or 1,800 acres for a 24 MW wind farm. As noted above, a majority of the 98-acre site is currently developed and there is not enough land space to site a wind turbine and generate even 1 MW of wind power on-site. Given this feasibility assessment, Vestas declined to provide further information regarding cost.

The design and efficiency of small wind energy systems has improved significantly in recent years. Aeromine Technologies has patented rooftop wind energy systems without blades that can be placed on flat commercial building rooftops. These devices must be positioned in locations where the wind direction is relatively constant because they are in a fixed position and cannot orient themselves. MFA attempted to contact Aeromine Technologies to inquire about the availability and pricing of their technology but have not received a response.

Foundation Windpower, LLC specializes in smaller scale wind energy systems for commercial properties. MFA contacted Foundation Windpower, LLC to inquire about the feasibility and cost of their technology. Although they have installed their systems ranging from 1 MW to 25 MW in California, they are not open to working on Oregon wind power installations at this time and

declined to discuss feasibility or pricing. Given further research on the viability of wind generation in this particular area, their position is unsurprising.

According to the U.S. Department of Energy's Land-Based Wind Market Report: 2022 Edition, although cost information is highly sensitive to project specific attributes, the average installed cost of wind turbines is \$1,600 per kW, or \$40 million for a 24 MW nameplate project.

Wind speeds and consistency are critical to the viability of wind generation. Wind speeds can vary throughout the day and the year, causing inconsistent electricity flow issues, and the amount of wind available depends on the location. Additionally, turbines have regular maintenance intervals that require them to shut down completely. Regular inspection of turbine components, lubrication of moving parts, and occasional cleaning are essential for optimal performance and longevity. The U.S. Energy Information Administration states that the annual average speeds for sufficient wind generation is at least 9 miles per hour for small wind turbines and 13 miles per hour for utility-scale turbines. MFA analyzed wind speed data from the National Oceanic and Atmospheric Administration's National Center for Environmental Information from Hermiston, Oregon for the 5-year period between 2018 to 2022. The average annual wind speed in the region was 7.39 miles per hour. Wind speeds in the area were above 9 miles per hour only 34 percent of the time and above 13 miles per hour only 14 percent of the time. Based on this information, wind energy systems at the site will not create enough energy to make the systems technically feasible and cost effective. Additional wind data is provided in Appendix B. Due to the large dataset, an excel file of the raw wind data will be provided electronically.

Battery storage helps to solve short-term variability issues, but there are also longer-term seasonal variations in weather patterns and meteorology. Onshore wind resources are strongest in the spring but may be greatly diminished in late summer and midwinter. Ideally, wind generation is located at sites with optimal wind conditions. Based on the data explained above, that would be a location several miles from the site. Moreover, during periods of low energy generation, PDX062 would not have sufficient and consistent output to be used at the site for this application.

Similar to solar energy, planning, permitting, and constructing a wind farm would also take years to complete. As illustrated by the extensive timeline to complete the B2H Transmission Line and ancillary and supporting facilities, construction of a wind farm to address the gap in electricity need is not a technically feasible option. Furthermore, the lack of transmission infrastructure continues to be a barrier to delivering such project's electrons to the utility.

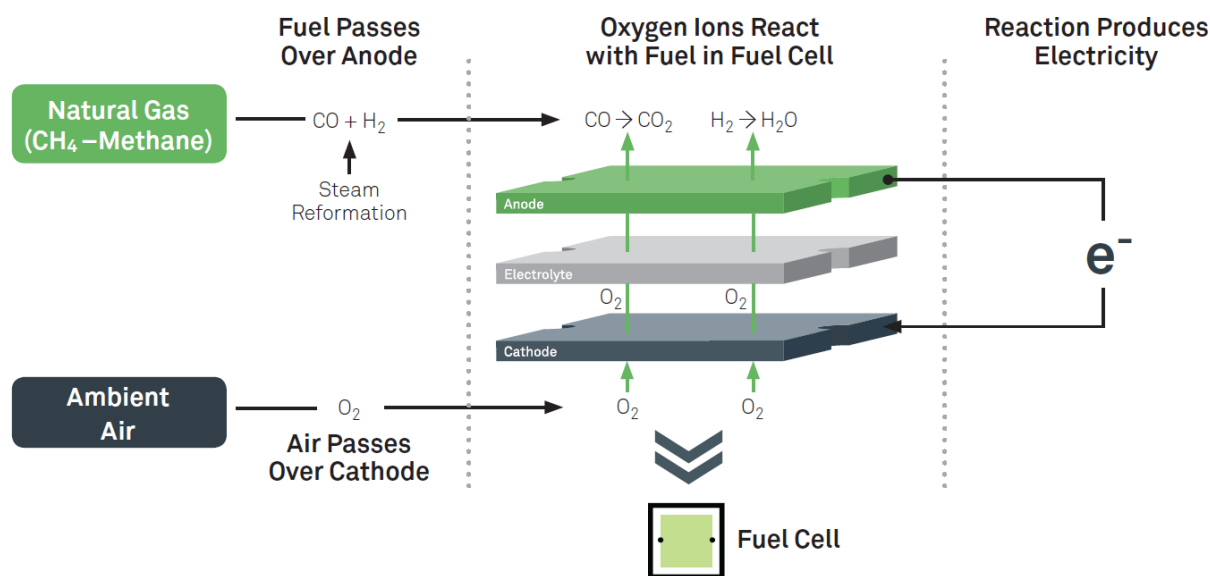
In accordance with OAR 340-271-0310, strategies considered in a BAER assessment must produce goods of comparable type, quantity, and quality. Wind energy is not a source of electricity that can be relied on with the constant demand need of the site and would not produce goods of comparable quality as compared to a more reliable source of energy.

Based on the inconsistency of the electrical generation, low wind speeds, the inability to locate a small wind developer with the ability to accommodate this site given its limitations, a prolonged timeline for developing the wind farm, and a lack of available transmission infrastructure, wind energy is considered technically infeasible for addressing any portion of the electricity needs at PDX062 in a comparable timeline, effectiveness, or efficiency as other options.

3.2.5 Bloom Energy SOFCs

The site is requesting to install Bloom Energy SOFCs as a continuous power source for the approximately six-year period prior to anticipated completion of the transmission infrastructure necessary to deliver additional electricity to ADS sites. SOFCs generate power by harnessing an electrochemical reaction between hydrogen from natural gas feedstock and oxygen in ambient air. The SOFC consists primarily of a fuel anode, an electrolyte, and a cathode, combined by interconnected plates to manage conductance and air flow in the system, as shown in Figure 3-2. The SOFC will supply the site as a supplement to the draw from the power grid.

Figure 3-2. Fuel Cell Process



The electrolyte material used in the Bloom Energy SOFC is designed to allow only oxygen ions to pass through the system, ensuring that other components of ambient air (nitrogen and CO_2) do not interfere or integrate into the process.

SOFCs do not use combustion to produce energy but rather use an anode to convert the natural gas into carbon monoxide and hydrogen, which are reacted with oxygen to produce CO_2 , water, and electricity. The SOFC consists of several fuel cell modules that are a fault-tolerant architecture, meaning that when maintenance is needed, these modules can be swapped out without any unit downtime, resulting in fewer emissions because there is no need to use backup diesel generators during maintenance activities.

The PDX062 site has access to natural gas. Gas Transmission Northwest (GTN), an interstate pipeline company, operates an interstate pipeline near the site. To serve ADS, it will permit, construct, and install connections between said interstate pipeline and PDX062 (ADS will not install or operate the pipeline lateral). Figure 3-3 in Appendix B presents the existing pipeline, along with the route of the future connections between the existing pipeline and PDX062.

Based on the discussion above, it is technically feasible for the Bloom Energy SOFC to provide the approximately 24 MW of electrical generation needed at PDX062 well in advance of the

transmission infrastructure that will allow local and regional electric utilities to supply additional electricity to the site.

3.2.5.1 SOFC Project Details

As an interstate pipeline operator, GTN has eminent domain authority and it is currently communicating that it will take approximately 9 to 12 months to design, permit, and construct the necessary connections, with construction scheduled to be completed by May 2024. Based on information received from SOFC vendors, ADS anticipates it will take six months to deliver, install, and start-up the fuel cells. As the installation of the SOFC cannot be completed without natural gas connections, we project the SOFC could be in service approximately 1 month after completion of the natural gas pipeline. Table 3-1 summarizes the proposed timeline for the project. Note, the current completion dates are dependent on the issuance of an air permit for this project by the DEQ.

Table 3-1. SOFC Timeline Summary

Item	Projected Timeline	Projected Completion Date
Lateral NG Pipeline Connection (design, permitting, and construction)	9 to 12 months	May 2024
Fuel Cells (delivery, installation, and startup)	6 months	June 2024

At the request of the DEQ, ADS has developed cost estimates for the SOFC project. Table 3-2 includes costs for construction of the natural gas pipeline connection to PDX062, and the purchase and installation of SOFCs. The total cost of the lateral pipeline is projected to be \$18.5 million, to be split equally among three sites. The cost listed below is allocated to PDX062. Note the costs are based on current projections and may change depending on the timeline of the DEQ's approval.

Table 3-2. SOFC Cost Summary

Item	Cost
Lateral NG Pipeline Connection (design and construction)	
Fuel Cells (equipment, delivery, installation, and startup)	
Total Project Cost (\$)	
Total Project Cost per MW (\$/MW)	

Table 3-3 outlines the permits and approvals ADS expects to be required for construction of the lateral pipeline route shown in Figure 3-3 of Appendix B.

Table 3-3. SOFC Permit and Consultation Summary

Permit/Approval	Administering Agency	Project Item
Consultation		
Section 7 of the Endangered Species Act	U.S. Fish and Wildlife Service (FWS)	Lateral NG Connection
State T&E	Oregon Biodiversity Information Center, Oregon Department of Fish and Wildlife, Oregon Department of Agriculture	Lateral NG Connection
Section 106	State Historic Preservation Office	Lateral NG Connection
Permit		
Construction Stormwater Permit	Oregon Department of Environmental Quality	Lateral NG Connection
Land Use Compatibility Statement	Morrow County	Lateral NG Connection
Prior Notice	Federal Energy Regulatory Commission	Lateral NG Connection
Zoning Permit	Morrow County	SOFC
Building Permit	Morrow County	SOFC
Mechanical Permit	Morrow County	SOFC
Plumbing Permit	Morrow County	SOFC
ACDP Modification	Oregon Department of Environmental Quality	SOFC
BAER Order	Oregon Department of Environmental Quality	SOFC

3.2.6 Bloom Energy SOFC and CO₂ Capture

The untreated anode exhaust stream from the Bloom Energy SOFC contains approximately 49.4 percent CO₂ on a dry basis, with the rest of the exhaust stream consisting of hydrogen and carbon monoxide. Because SOFCs do not use combustion, co-pollutants such as sulfur oxide and nitrogen oxide emissions are virtually eliminated. The following methods were considered to capture the CO₂ and process it into a marketable stream:

- Water gas shift reactor in combination with a dehydrator and further separation.
- Activated carbon-based CO₂ adsorption.

In Executive Order 20-04, Governor Brown directed the Oregon Global Warming Commission to work in coordination with the Oregon Department of Agriculture, the Oregon Department of Forestry, and the Oregon Watershed Enhancement Board to develop and submit a proposal for setting a carbon sequestration and storage goal for Oregon's natural and working lands. In July 2020, the Oregon Global Warming Commission adopted principles for developing a net carbon sequestration and storage goal for Oregon's natural and working lands; however, at the time of this report, underground CO₂ injection and sequestering is currently illegal in Oregon. Furthermore, underground sequestration could not be designed, permitted, and constructed prior to completion of infrastructure upgrades such as the B2H Transmission Line and the ancillary and supporting

facilities needed to deliver electricity to the site. For these reasons, this method was considered technically infeasible.

A water gas shift reactor in combination with a dehydrator can result in a 98.8 percent CO₂ stream, while activated carbon CO₂ adsorption can result in a 93 percent CO₂ stream that can be packed and sold as product. The site spoke with several potential partners to find a demand for purified CO₂, and it was determined that there is currently not enough demand in the market for CO₂ in Oregon. Exacerbating this situation is the fact that the supply is time-limited such that no new off-taker will locate in Oregon, where the source of CO₂ is not expected to exist until after approximately 2031. Since there is no commercially available outlet for the captured CO₂, carbon capture and sequestration or sale is not a feasible option at this time. A letter outlining the efforts to find market demand for purified CO₂ in Oregon is included in Appendix E.

Based on the discussion above, the Bloom Energy SOFC with CO₂ capture is infeasible in Oregon at this time.

3.2.7 Bloom Energy SOFC with RNG as Feedstock

RNG is any pipeline-compatible gaseous fuel derived from biogenic or other renewable sources that has lower lifecycle CO₂e emissions than geological natural gas. RNG is produced by capturing emissions from existing waste streams found in landfills, water treatment plants, and animal manure. The gas must be treated and cleaned to reach the standard at which it can be injected into existing gas pipelines. RNG combines low to negative life-cycle carbon emissions with the high-energy density storage capability and transportability of natural gas.

Bloom Energy SOFC technology currently uses natural gas as the feedstock. The site considered the option of using RNG if available. However, Oregon only produces approximately 1,100 million British thermal units (MMBtu) per day of RNG that is injected into a pipeline, all of which is provided by Threemile Canyon Farms in Boardman, Oregon. Threemile Canyon Farms operates a methane digester and began providing pipeline quality gas to California for RNG transportation fuel in 2019. The RNG being injected into the pipeline is subject to long-term contracts and little to no gas is available for a short-term contract covering the anticipated life of the SOFC equipment.

The remaining operational biogas plants are consuming the supply onsite. ADS has engaged with Oregon biogas plants to procure regionally sourced RNG. ADS contacted the Port of Morrow to inquire about acquiring the rights to the raw biogas that will be generated at the Boardman Wastewater facility currently under construction. At this time, the Port has not released an RFP for the project and has indicated that they are several months from doing so. Lamb Weston has yet to announce plans to offer biogas produced in Hermiston to outside sources. While future resources may become available in the next few years, they remain highly speculative. Table 3-4 below presents a summary of potential sources of RNG and the availability of the RNG to PDX062.

Table 3-4. RNG Availability Summary

RNG Source	RNG End Use
Threemile Canyon Farms	Transportation Sector
Port of Morrow	RNG project is under construction. No RFP has been issued at this time.
Lamb Weston	On-site usage

If viable supplies were available, Bloom SOFC using RNG as supplemental feedstock would be a technically feasible option. However, it is highly speculative that short-term contracts consistent with the proposed temporary use of the SOFC equipment could be obtained, given the market's interest in longer-term sales. As a result, the use of RNG is eliminated at this time as technically infeasible. The feasibility of obtaining RNG can be reassessed when this determination is updated in 5 years if the SOFC equipment is still in use.

3.2.8 Bloom Energy SOFC with RNG Attributes

Off-site GHG reductions could potentially be used to show “paperwork” reductions in emissions from the site. Such reductions can exist in the form of offsets or attributes. Offsets represent MT of emissions avoided or reduced, while attributes represent 1 MWh of renewable electricity generation. RNG attributes are used in renewable energy markets to account for electricity generated using RNG, whether that electricity is generated at the organization's facility or purchased from elsewhere, potentially even another state or country. The common element of offsets and attributes is that, by definition, neither offsets nor attributes reflect a reduction of GHG emissions at the covered stationary source.

According to OAR 340-271-0320(1):

A BAER order will establish the actions that the owner or operator of a covered stationary source must take to reduce covered emissions and the timeline on which the actions must be taken.

Covered emissions as defined in OAR 340-271-0110(5)(b)(A) are:

Emissions of anthropogenic greenhouse gases in metric tons of CO₂e that would result from the complete combustion or oxidation of the annual quantity of propane and liquid fuels (including, for example and without limitation, gasoline and petroleum products) imported, sold, or distributed for use in this state.

The site's covered emissions are the emissions generated only at the site and nowhere else in the state or country. Therefore, ADS previously understood that RNG attributes generated off site would not reduce the site's covered emissions. In a July 11, 2023 letter, the DEQ indicated that their interpretation of the current rules differs and that “sources subject to CPP, including BAER sources, may procure biomethane using a book-and-claim approach in order to reduce covered emissions.” Based on this guidance, ADS reached out to multiple firms for purchase of RNG attributes. Given the volume of natural gas usage (approximately 4,100 MMBtu/day), ADS was unable to secure terms for the attributes to cover the entire natural gas volume. Table 3-5 presents the cost of the of the RNG attributes on a MMBtu basis.

Table 3-5. RNG Attribute Cost Analysis

RNG Attribute Source	Quantity (MMBtu/day)	Cost (\$/MMBtu)
Total – RNG Attributes for 3 Sites	4,500-4,750	--
Total – RNG Attributes for Each Site	1,500-1,583	--

It should be noted that the above terms are preliminary estimates provided by the two firms and no formal binding agreement has been made with either source. As such, the terms are subject to change prior to formal agreement. Term letters from the responsive firms are in Appendix F.

3.2.9 Bloom Energy SOFC with Hydrogen

Bloom Energy SOFC technology has an internal equipment upgrade available that allows the SOFC to use a 50/50 hydrogen/natural gas blend. Additionally, the servers can further be upgraded with a module to process 100 percent hydrogen as it becomes available. A hydrogen/natural gas feedstock source or strictly hydrogen as a feedstock source would eliminate anywhere between 50 to 100 percent of the GHG emissions if the hydrogen source becomes available in the future.

ADS is involved in the Pacific Northwest Hydrogen Association Board, PNWH2 grant programs and the Fuel Cell and Hydrogen Energy Association. ADS is committed to investing time and resources to find a cleaner solution while also working with the Department of Energy's Hydrogen Hubs initiative to create a hydrogen hub in the Pacific Northwest that could serve its data center in the future. ADS is actively working to increase the availability of alternative fuels for use in projects such as this one, but they are currently unavailable.

3.2.9.1 Methane Pyrolysis

Methane pyrolysis is a process involving thermal decomposition of methane at high temperatures into its constituent elements, hydrogen, and solid carbon. The heat required in the reaction can be generated in a number of ways. One method involves using an electric current to heat up a resistive wire or heating element. This heat is then transferred to the reaction chamber containing the methane, causing it to break down into hydrogen and carbon. Another approach is to use combustion to generate the necessary heat. In this case, a fuel source such as natural gas or propane is burned in a combustion chamber, and the resulting heat is used to drive the reaction.

One of the main challenges with methane pyrolysis is the high energy input required to achieve the desired reaction temperatures. The temperature range for methane pyrolysis is approximately 800 to 1,100 degrees Celsius, and achieving these temperatures requires a significant amount of energy. The use of fossil fuels to provide the necessary heat results in the production of GHGs, which defeats the purpose of using methane pyrolysis as a clean energy source. In addition, using an electric current to achieve pyrolysis requires significant quantities of electricity which ADS cannot obtain at this time due to infrastructure shortcomings. Once those infrastructure shortcomings are resolved, there will be no need for the SOFCs.

Another challenge facing methane pyrolysis is the difficulty in separating the hydrogen from the solid carbon produced in the process. If not done properly, the hydrogen gas can become contaminated with impurities such as carbon monoxide and CO₂. The purity of hydrogen can also be affected by the reactor design, operating conditions, and catalysts used.

Currently the process is performed at laboratory scale, and there are no industrial-scale methane pyrolysis plants in operation. According to Lux Research, several startups have been founded to develop methane pyrolysis technologies that were originally developed at research institutions; however, the technology is still in the development stage and is not ready for large scale platforms. Netherlands Organization for Applied Scientific Research and the Karlsruhe Institute of Technology have scaled their technology to pilot installations but have stated that a commercial-scale facility is unlikely before 2030 (Daliah, 2021). Additionally, in a project funded by the Federal Ministry of Education and Research, BASF has been developing methane pyrolysis technology for several years. The technology is still in the testing phase, and BASF estimates that methane pyrolysis will likely be available for large-scale production in 2030 (BASF, 2021).

MFA contacted Monolith Corp on May 18, 2023, to inquire about their methane pyrolysis technology. Monolith has established itself as a technology leader in methane pyrolysis, providing hydrogen and carbon black from natural gas. Monolith indicated that at this time they are unable to provide the technology to support this project. They are currently developing a second larger facility that will be built next to their current facility in Hallam, Nebraska, and are interested in future partnerships as their capacity increases.

Modern Hydrogen located in Bothell, Washington, is developing methane pyrolysis devices that are smaller, modular, and intended for decentralized applications, so the hydrogen gas won't have to be shipped or piped to new locations. Modern Hydrogen has pilot projects planned, including one with NW Natural, and intends to ship its demonstration reactors to utilities by the end of 2023. However, the technology is still in the pilot phase, and is not commercially available at this time. MFA contacted Modern Hydrogen on June 5, 2023, to inquire about the availability of their technology. The estimated timeline for commercially available units capable of generating 24 MW of electricity is approximately 2027.

Planning, permitting, and constructing the necessary infrastructure is estimated to take several years to complete. As the infrastructure upgrades of the B2H Transmission Line and other ancillary and supporting facilities needed to deliver electricity to the site are scheduled to be operational by approximately 2031, construction of a pyrolysis plant to produce hydrogen and address the gap in electricity need is not a technically feasible option as a replacement. Hydrogen is not expected to be an available option during the limited life of SOFC at the site. Therefore, the Bloom Energy SOFC with hydrogen as feedstock is not technically feasible at this time.

3.2.10 Fossil Fuel-Fired Generators

The PDX062 site air permit currently authorizes ADS to operate 107 emergency generators, for a total capacity of 261.5 megawatts (MW). The air permit does not authorize these engines for baseload power generation. However, ADS could obtain 24 MW of diesel or natural gas-fired internal combustion engines connected to generators and seek permitting authority to construct and operate these units during the time period before infrastructure improvements are completed to provide the facility's full needs. However, diesel-fired internal combustion engines are not an ideal

solution because of noise emissions, increased GHG, criteria pollutant, and toxic air pollutant emissions.

Internal combustion engines require regular maintenance and replacement of parts. Compliance with the following management practice requirements for each permitted stationary reciprocating internal combustion engine includes but is not limited to the following:

- Change oil and filter every 500 hours of operation or annually, whichever comes first;
- Inspect air cleaner every 1,000 hours of operation or annually, whichever comes first, and replace as necessary;
- Inspect hoses and belts every 500 hours of operation or annually, whichever comes first, and replace as necessary; and,
- If a stationary reciprocating internal combustion engine is operating during an emergency and it is not possible to shut down the engine in order to perform the management practice requirements on schedule, or if performing the management practice on the required schedule would otherwise pose an unacceptable risk under federal, state, or local law, the management practice can be delayed until the emergency is over or the unacceptable risk under federal, state, or local law has abated. The management practice must be performed as soon as practicable after the emergency has ended or the unacceptable risk under federal, state, or local law has abated.

This maintenance could cause disruptions to the power supply, leading to downtime and putting facility operations at risk. However for purposes of this analysis, the use of internal combustion engines to drive generators is considered technically feasible to provide the approximately 24 MW of electrical generation needed at PDX062 prior to completion of the infrastructure necessary to serve the site.

3.2.11 Combined-Cycle Power Plant

A combustion-based energy-generating plant uses primarily combustion turbines, heat-recovery steam generators (or boilers), and steam turbines to convert natural gas, biomass, or diesel fuel to electricity. A combined-cycle power plant uses both a gas and a steam turbine together in a three-step process. First, the gas turbine burns fuel. The gas turbine compresses air and mixes it with fuel that is heated to a high temperature. The hot air and combustion gas mixture moves through the gas turbine blades, making them spin. Next, a heat recovery system captures exhaust heat from the gas turbine that would otherwise escape through the exhaust stack. The waste heat from the gas turbine is routed to the nearby steam turbine, which generates extra electricity.

According to the U.S. Department of Energy Combined Heat and Power Technology Fact Sheet, typically routine inspections are required every 4,000 hours to ensure that the turbine is free of damaged blade tips or excessive vibration from worn bearings and rotors (U.S. Department of Energy 2016). In addition, a gas turbine overhaul is needed every 25,000 to 50,000 hours; this typically includes a complete inspection and rebuild of components to restore the gas turbine to performance standards. Maintenance will require shutdown, leaving the site running on backup diesel generators. For each hour of shutdown, diesel generators will require approximately 1,630 gallons of diesel fuel to generate 24 MW of electricity, resulting in emissions of over 18 tons of GHG per hour. This will also result in an additional increase in criteria and hazardous air pollutant

(HAP) emissions, as well as putting continuous operations at risk by running on a backup power source.

Designing, permitting, and constructing a new 24-MW combined-cycle power plant would take a minimum of three to six years. Given that the site requires on-site electricity generation to cover the shortfall today, a combined-cycle power plant is not a technically feasible option.

3.3 Step 3—Rank Remaining Power Sources/Emission Reduction Options by Effectiveness

Based on the above analysis, the following technologies were determined to be technically feasible and commercially available for providing on-site electricity generation prior to completion of the infrastructure upgrades of the B2H Transmission Line and the ancillary and supporting facilities. The technologies are ranked in order from the least carbon intensive to the most carbon intensive:

1. Bloom Energy SOFC with natural gas as fuel plus 1,583 MMBtu/day of RNG attributes (679 to 833 pounds CO₂e per MWh [lb CO₂e/MWh]).
2. Bloom Energy SOFC with natural gas as fuel plus 1.2 MW rooftop solar (679 to 833 lb CO₂e/MWh).
3. Bloom Energy SOFC with natural gas as fuel (679 to 833 lb CO₂e/MWh).
4. Natural gas-fired internal combustion engines connected to generators (1,199 lb CO₂e/MWh).
5. Diesel-fired internal combustion engines connected to generators (1,243 lb CO₂e/MWh).

3.4 Step 4—Evaluation of the Most Effective Power Source/Emission Reduction Option

The next step in the BAER evaluation is to assess the highest-ranking technology on the basis of energy, environmental, and economic impacts. However, if the highest-ranking technology is being proposed for utilization, this stage of the review is not necessary.

3.4.1 Bloom Energy SOFCs Using Natural Gas as Fuel plus 1,583 MMBtu/day of RNG Attributes

3.4.1.1 Energy Impacts

The Bloom Energy SOFCs will use natural gas as fuel to operate. The SOFCs require approximately 4,100 MMBtu/day to operate. As noted in Section 3.2.8, Bloom Energy could potentially purchase up to 1,583 MMBtu/day per site of renewable natural gas attributes. This would cover 38 percent of daily fuel needs.

3.4.1.2 Environmental Impacts

Bloom Energy SOFC technology is described in detail above. This technology generates electricity by oxidizing feedstock such as natural gas. As no combustion is involved, the criteria pollutant emissions from the units are very low compared to electrical generation technologies using combustion. Bloom Energy's fuel cells also operate at some of the highest electrical efficiencies of

any gas-based power generation device and, therefore, need less natural gas to generate the same amount of power as a combustion alternative, driving a lower GHG emissions profile. When oxidizing conventional natural gas, the Bloom Energy technology has a GHG emission rate of between 679 and 833 lb CO₂e/MWh. This is significantly lower than the Oregon Department of Energy's GHG emissions standard for electrical generating facilities, 1,100 lb CO₂/MWh (OAR 330-180-0030(1)) or the Oregon GHG Emissions Performance Standard for new baseload electricity generation of 1,100 lb CO₂e/MWh (Oregon Revised Statute 757.524). It is also significantly lower than the emissions from "marginal" power sources Bloom Energy's technology might displace if grid power were available in the relevant eGrid region (NWPP). The 2021 non-baseload emission rate for the NWPP Region was 1,626.75 lb CO₂/MWh (EPA 2023).

The Bloom Energy SOFC offers a significant benefit when it comes to water consumption as compared to the marginal grid. The SOFC uses 0.69 gallons of water per MWh. Compared to consumption by the marginal grid of 740 gallons per MWh (USGS 2018), the Bloom technology offers a reduction of greater than 99.9 percent.

Bloom Energy technology also presents opportunities not found in other conventional generation methods. Bloom Energy's fuel cells are essentially feedstock neutral and are capable of employing natural gas, RNG, or hydrogen to the extent that these feedstocks are available. As a result of this feedstock flexibility and the short-term need for addressing a shortfall in electricity available from other sources, the Bloom technology is not an investment that locks ADS or Oregon into long-term commitments that make climate improvement difficult. This is a key concern, as technologies that require long-term installations make short-term change impossible. Adding to this flexibility is the fact that the Bloom Energy technology is skid-mounted and so can be moved in, and moved out, easily. This makes the Bloom Energy SOFC technology ideal for the current application where a short-term need for on-site electrical generation is critical to the operation of the site. No other technology offers this combination of feedstock flexibility and ease of short-term utilization.

No increases to or changes in emission rates related to required repairs of the equipment are anticipated. Malfunctioning components of the system will be replaced in lieu of shutdown if repairs to the system are needed.

In a book-and-claim-system, a contracted amount of RNG is introduced into a distribution system and an equal amount of energy is withdrawn at another location. The environmental attributes corresponding to the RNG are transferred through an exchange of certificates between the producer and buyer to establish chain of custody and ownership of the energy and associated emissions reductions. Although actual onsite GHG emissions would be higher because the site will still need to use 4,100 MMBtu/day to operate, total emissions from a book-and-claim perspective would be lower due to the purchase of RNG attributes. Although criteria pollutant and HAP emissions will not be reduced by the addition of RNG attributes, GHG is a global pollutant, so using RNG attributes will result in a net reduction of GHG.

Table 3-6 below highlights the comparable environmental impacts resulting from the use of Bloom Energy SOFC plus 1,583 MMBtu/day of book-and-claim RNG attributes.

Table 3-6. Bloom Energy SOFC Installation Plus RNG Attributes Air Emissions

Pollutant	SOFC Emission Factor (lb/MWh)	Hourly Emission Rate (lb/hr)	Annual Emission Rate (tons/yr)
PM	0.022	0.53	2.34
PM ₁₀	0.022	0.53	2.34
PM _{2.5}	0.015	0.36	1.60
SO ₂	5.95E-06	1.45E-04	6.33E-04
NO _x	0.0017	0.041	0.18
CO	0.012	0.29	1.28
VOC	0.010	0.24	1.06
GHG	833	12,550	54,969
HAP	3.64E-04	0.0088	0.039
Notes Criteria pollutant and HAP emission estimates are based on 24.3 MW. GHG emission estimates are based on a net reduction of gas combustion of approximately 38 percent. CO = carbon monoxide. GHG = greenhouse gas. HAP = hazardous air pollutant. hr = hour. lb = pound. MWh = megawatt-hour. NO _x = nitrogen oxides. PM = particulate matter. SO ₂ = sulfur dioxide. SOFC = solid oxide fuel cell. VOC = volatile organic compound. yr = year.			

The SOFC emission factors are based on the emission factors provided by the manufacturer specification sheet except for sulfur dioxide. The sulfur dioxide emission factor is calculated based on the expected sulfur content in the pipeline natural gas which is 0.5 grains per 100 standard cubic feet (scf).

$$SO_2 \left(\frac{lb}{MWhr} \right) = \left(\frac{Fuel\ Consumption \left(\frac{scf}{hr} \right)}{Rated\ Power\ (MW)} \right) \times \left(\frac{lbmol\ NG}{359\ scf\ NG} \right) \times \left(\frac{0.005\ lbmol\ SO_2}{10^6\ lbmol\ NG} \right) \times \left(\frac{64\ lb\ SO_2}{lbmol\ SO_2} \right)$$

Where:

$$Fuel\ Consumption = Rated\ Power \times Heat\ Rate \left(6,562 \frac{BTU\ LHV}{kWhr} \right) / NG\ LHV(983\ BTU/SCF)$$

$$Rated\ Power = 24.3\ MW$$

3.4.1.3 Economic Impacts

MFA prepared an annual cost-effective analysis, comparing the CO₂e emitted from each power source to the CO₂e emitted from the marginal grid. The annual cost effectiveness of purchasing RNG attributes, assuming Bloom Energy can purchase the maximum amount available today at \$27

per MMBtu, is \$383 per ton of CO_{2e} reduced as compared to the marginal grid. Cost effectiveness tables are included in Appendix G.

The social cost of carbon refers to the economic impact associated with each additional ton of carbon dioxide emissions released into the atmosphere. This cost accounts for the damage caused by climate change, including impacts on human health, agriculture, infrastructure, and ecosystems. By using the social cost of carbon, governments can estimate the monetary value of these damages and incorporate them into policy decisions. Policymakers can compare the projected costs of implementing specific policies with the estimated benefits, including the reductions in future damages associated with lower emissions.

The Obama administration initially estimated the social cost of carbon at \$43 per ton globally, while the Trump administration estimated between \$3 and \$5 per ton, only considering the effects of carbon within the United States. The Biden administration set the social cost of carbon at \$51. However, in November 2022, the EPA proposed an increase to \$190 and is weighing public comments on the proposal. Comparing even the highest current estimate of social cost of carbon, \$190 per ton, to the annual cost effectiveness of \$383 per ton, the SOFC installation with RNG attributes is not the most economically feasible.

3.4.2 Bloom Energy SOFC Using Natural Gas as Fuel and Rooftop Solar

3.4.2.1 Energy Impacts

Using natural gas as feedstock to operate, the Bloom Energy SOFC requires 162,214 scf/hr at capacity, or 1,421 MMscf/yr. Incorporating 1.2 MW of solar is technically possible and if included as an addition to the SOFC would not reduce the required natural gas needed. If rooftop solar was included to replace a portion of the energy generated by the fuel cells the natural gas consumption would be reduced by just 5 percent.

The energy generation estimate is based on the average energy generated over a given year. Weather events and time of day will cause periods when the solar energy generation is zero and the power provided to the facility will be the maximum capacity the fuel cells can provide. The inclusion of onsite solar energy results in an offset of the carbon impacts of 4,379 tons of CO_{2e} per year.

3.4.2.2 Environmental Impacts

Similar environmental impacts for the SOFC are found as described above in Section 3.4.1.2, however, total emissions are slightly lower due to the incorporation of solar. Table 3-7 below highlights the comparable environmental impacts resulting from the installation of the Bloom Energy SOFC plus a rooftop solar installation.

Table 3-7. Bloom Energy SOFC Installation Plus Rooftop Solar

Pollutant	SOFC Emission Factor (lb/MWh)	Hourly Emission Rate (lb/hr)	Annual Emission Rate (tons/yr)
PM	0.022	0.51	2.23
PM ₁₀	0.022	0.51	2.23
PM _{2.5}	0.015	0.35	1.52
SO ₂	5.95E-06	1.37E-04	6.02E-04
NO _x	0.0017	0.039	0.17
CO	0.012	0.28	1.21
VOC	0.010	0.23	1.01
GHG	833	19,242	84,281
HAP	3.64E-04	8.41E-03	0.037
Notes Criteria pollutant and HAP emission estimates are based on 23.1 MW. CO = carbon monoxide. GHG = greenhouse gas. HAP = hazardous air pollutant. hr = hour. lb = pound. MWh = megawatt-hour. NO _x = nitrogen oxides. PM = particulate matter. SO ₂ = sulfur dioxide. SOFC = solid oxide fuel cell. VOC = volatile organic compound. yr = year.			

This analysis does not take into account the addition of batteries to accompany the rooftop solar. The batteries would represent additional cost but not provide significant additional benefit for this application. Most batteries used in conjunction with rooftop solar systems are lithium-ion batteries, which tend to degrade gradually over the course of several years and would increase capital and operating costs over the life of the facility. Furthermore, batteries are somewhat redundant to the purpose and application of the SOFC. No net additional capacity would be gained by installing an appropriately sized battery with this rooftop solar installation.

3.4.2.3 Economic Impacts

The annual cost effectiveness of using the Bloom Energy SOFC with rooftop solar, is \$396 per ton of CO₂e reduced as compared to the marginal grid. When compared to the highest estimate of the social cost of carbon, \$190 per ton CO₂e, the SOFC with rooftop solar is not economically feasible. Cost effectiveness tables are included in Appendix G.

3.4.3 Bloom Energy SOFC Using Natural Gas as Fuel

3.4.3.1 Energy Impacts

The Bloom Energy SOFC will use natural gas as feedstock to operate. The Bloom Energy SOFC requires 162,214 scf/hr at capacity, or 1,421 MMscf per year per unit.

3.4.3.2 Environmental Impacts

The environmental impacts of the Bloom Energy SOFC technology is described in detail above. Installation and operation of the SOFC will result in emissions of criteria pollutants, HAPs and GHGs. A summary of the potential emissions at the site are summarized in Table 3-8 below. The emissions assume continuous operations. Table 3-8 highlights the comparable environmental impacts resulting from the utilization of only the Bloom Energy SOFC.

Table 3-8. Bloom Energy SOFC Installation Air Emissions Summary

Pollutant	SOFC Emission Factor (lb/MWh)	Hourly Emission Rate (lb/hr)	Annual Emission Rate (tons/yr)
PM	0.022	0.53	2.34
PM ₁₀	0.022	0.53	2.34
PM _{2.5}	0.015	0.36	1.60
SO ₂	5.95E-06	1.45E-04	6.33E-04
NO _x	0.0017	0.041	0.18
CO	0.012	0.29	1.28
VOC	0.010	0.24	1.06
GHG	833	20,242	88,660
HAP	3.64E-04	0.0088	0.039
Notes Criteria pollutant and HAP emission estimates are based on 24.3 MW. CO = carbon monoxide. GHG = greenhouse gas. HAP = hazardous air pollutant. hr = hour. lb = pound. MWh = megawatt-hour. NO _x = nitrogen oxides. PM = particulate matter. SO ₂ = sulfur dioxide. SOFC = solid oxide fuel cell. VOC = volatile organic compound. yr = year.			

3.4.3.3 Economic Impacts

The annual cost effectiveness of using the Bloom Energy SOFC with natural gas as feedstock is \$351 per ton of CO₂e reduced as compared to the marginal grid. Cost effectiveness tables are included in Appendix G.

3.5 Step 5—Select BAER

Table 3.9 summarizes the annual cost effectiveness of the three technologies analyzed for economic impacts.

Table 3-9. Annual Cost Effectiveness Summary

Technology	Cost Effectiveness (\$/ton CO₂e reduced)
SOFC	\$351
SOFC plus RNG Attributes	\$383
SOFC plus 1.2 MW Rooftop Solar	\$396

Based on the discussions in the previous sections, the Bloom Energy SOFC using natural gas as feedstock is the alternative that best fits the regulatory criteria for establishing BAER for this temporary on-site generation project of approximately 24 MW. The addition of 1.2 MW of rooftop solar, while technically feasible, is not economically feasible and does not diminish the need for the full 24 MW of SOFC generation. The purchase of RNG attributes is also not economically feasible. However, it is understood that the program currently has an established level of control that must also be considered in making this determination. Once a BAER order has been issued, covered stationary sources must submit an annual report on progress toward implementing requirements of the BAER order as well as submitting a five-year review report identifying all strategies to reduce covered emissions available at that time.

LIMITATIONS

The services undertaken in completing this report were performed consistent with generally accepted professional consulting principles and practices. No other warranty, express or implied, is made. These services were performed consistent with our agreement with our client. This report is solely for the use and information of our client unless otherwise noted. Any reliance on this report by a third party is at such party's sole risk.

Opinions and recommendations contained in this report apply to conditions existing when services were performed and are intended only for the client, purposes, locations, time frames, and project parameters indicated. We are not responsible for the impacts of any changes in environmental standards, practices, or regulations subsequent to performance of services. We do not warrant the accuracy of information supplied by others, or the use of segregated portions of this report.

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APPENDIX A

ACDP PERMIT MODIFICATION APPLICATION

June 13, 2022

Ania Loyd, Environmental Engineer
Oregon Department of Environmental Quality
475 NE Bellevue Dr., Suite 210
Bend, OR 97701-7415

*RE: ACDP Technical Permit Modification
Amazon Data Services PDX-62, 75300 Lewis and Clark Dr., Boardman, OR 97818*

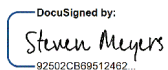
Ms. Loyd,

Amazon Data Services, Inc. (ADS) hereby submits the attached Moderate Complexity Technical Permit Modification to Air Contaminant Discharge Permit (ACDP) No. 25-0029-ST-01, for an air contaminant source at a facility in Boardman, Oregon (PDX-62).

The format and content of this application are consistent with the Department's current policy for ACDP technical modification applications; it is a complete application package using the most current application forms. Enclosed is one electronic copy of the application, including Responsible Official certification by Steven Meyers, Authorized Representative. Hard copies will be provided upon request.

If you have any questions or comments about the information presented in this NC application package, please do not hesitate to call Jason Bowker at 541.303.2380 or Beth Ryder at 458.206.6770.

Sincerely,

DocuSigned by:

92502CB89512462
Steven Meyers, Authorized Representative
Amazon Data Services, Inc.

cc: Beth Ryder (Trinity Consultants)
Rachel Reese (Trinity Consultants)
Garrett Koehler (Amazon Data Services)
Jason Bowker (Amazon Data Services)

ACDP MODIFICATION APPLICATION

Fuel Cell Installation

Amazon Data Services - PDX62

Beth Ryder – Managing Consultant
Rachel Reese – Senior Consultant

TRINITY CONSULTANTS

12725 SW Millikan Way
Suite 300
Beaverton, OR 97005
503.906.7833

June 2022

Project 213801.0023



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1. EXECUTIVE SUMMARY

Amazon Data Services, Inc. (ADS) owns and operates the PDX-62 data center in Boardman, Oregon (PDX-62) under Oregon Department of Environmental Quality (Oregon DEQ) Standard Air Contaminant Discharge Permit (ACDP) No. 25-0029-ST-01 issued April 20, 2018. The facility is considered a synthetic minor under the Title V program.

This permit modification requests approval to install solid oxide fuel cells (SOFC) as a continuous power source with a capacity of 24.3 megawatts (MW). The SOFC will be used in addition to electricity provided by utility. The proposed new equipment will cause an increase in several regulated pollutant emissions. Pursuant to Oregon Administrative Rule (OAR) Chapter 340-216-0020(7), no person may increase emissions above the Plant Site Emission Limit (PSEL) by more than the de minimis emission levels specified in OAR 340-200-0020 without first applying for and obtaining a modified ACDP. This project will request an increase above the current greenhouse gas (GHG) PSEL by 18,054 tons per year (tpy). Therefore, the proposed changes are requested by ADS as a Type 3 change and as such require a permit modification application be submitted to Oregon DEQ.¹ This ACDP modification is expected to be classified as a “moderate” technical modification; therefore, a corresponding fee of \$9,000 has been submitted to Oregon DEQ.²

In accordance with OAR 340-216-0040(3), this application details the requested changes to the permit and new applicable requirements. ADS has considered the timelines provided in OAR 340-216-0040(2)(b) and is submitting this application sufficiently in advance to allow Oregon DEQ adequate time to process the application and issue a permit before it is needed. ADS is also requesting the removal of the sulfur dioxide (SO₂) PSEL, as facility wide emissions are less than de minimis levels.

The following Oregon DEQ forms are included in Appendix A:

- ▶ Administrative Information (AQ101);
- ▶ Facility Description (AQ102);
- ▶ Miscellaneous Processes and Devices (AQ230);
- ▶ Plant Site Emissions Detail (AQ402);
- ▶ Hazardous Air Pollutant Emission Details (AQ403); and
- ▶ Land Use Compatibility Statement.

¹ Per OAR 340-210-0225(4).

² ADS is required to pay Permit Modification fee of \$9,000 pursuant to OAR 340-216-8020, Table 2, Part 4, and OAR 340-216-0030(3).

2. FACILITY AND PROJECT DESCRIPTION

2.1 Facility Description

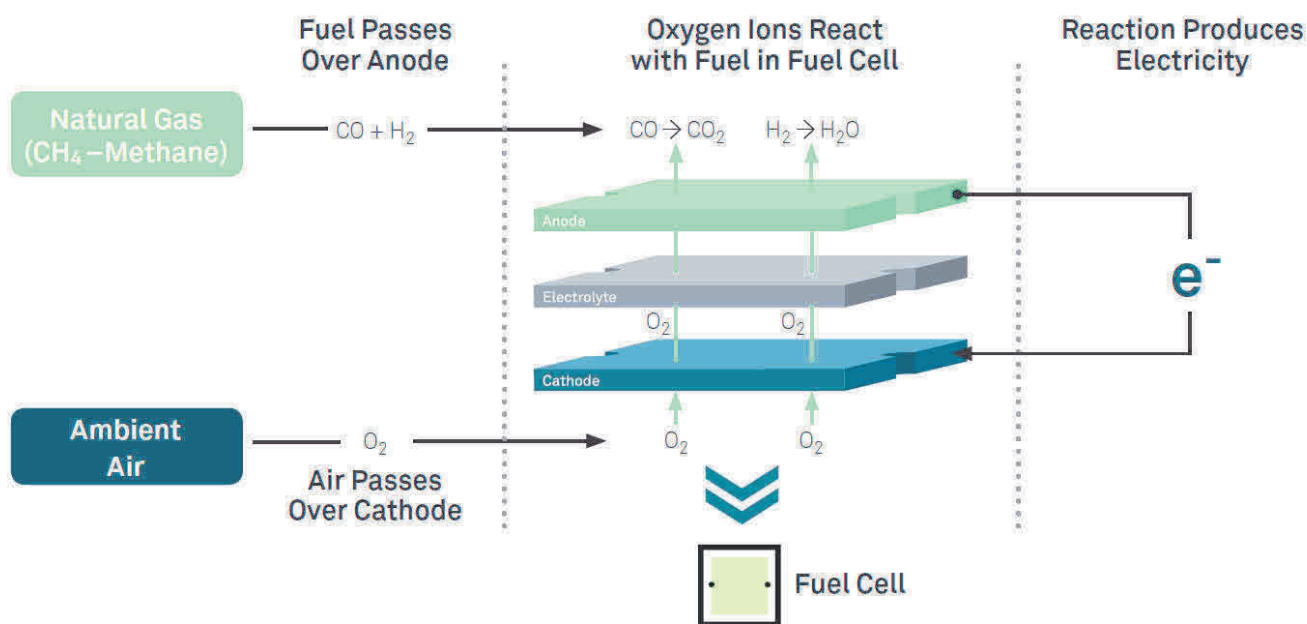
PDX-62 is located at 75300 Lewis and Clark Drive in Boardman, Oregon. The facility houses computer systems and associated components, such as telecommunications and data storage systems. Equipment at the facility includes security systems, data communications equipment, environmental controls, backup emergency power supplies (generators), and emergency fire pumps. The principal use of the facility is the storage, management, and dissemination of electronic data. A total of 108 diesel fired emergency engine-generators and two fire pumps are the currently approved emission sources at the facility.

2.2 Project Description

2.2.1 Solid Oxide Fuel Cell Source Description

SOFC generate power by harnessing an electrochemical reaction between hydrogen from natural gas fuel and oxygen in the ambient air. Figure 2-1 below shows a typical SOFC design, which consists primarily of an anode, an electrolyte, and a cathode, combined by interconnect plates to manage conductance and air flow in the system.

Figure 2-1. Solid Oxide Fuel Cell Technology ³



Air contaminant emissions resulting from SOFC operation will include particulate matter (PM, PM_{2.5} and PM₁₀), SO₂, nitrogen oxides (NO_x), carbon monoxide (CO), volatile organic compounds (VOCs), and greenhouse gas (GHG) emissions of carbon dioxide (CO₂). The electrolyte material utilized in the Bloom Energy SOFC is designed to only allow oxygen ions to pass through the system, ensuring other components of the ambient air (Nitrogen, Carbon Dioxide) do not interfere or integrate into the process. This characteristic of the electrolyte, as well as the lack of combustion or thermal reaction, virtually eliminates NO_x, SO₂ and other smog forming emissions from the units.

³ Bloom Energy Corporation; Technical Note - A Primer to Understanding Fuel Cell Power Module Life; 2019.

2.2.2 Facility SOFC Source Operation

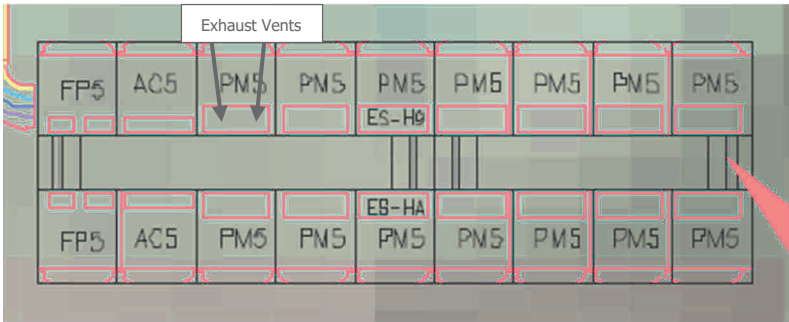
SOFC generated electricity at PDX-62 will be used as a primary power source to reduce the electrical draw from site operations from the power grid; helping to ensure reliability of the system. The SOFC system is designed to generate 24.3 MW. The system is expected to run continuously at this capacity. If required, there will be no increases or changes in emission rates anticipated related to repairs of the equipment. Malfunctioning components of the system will be replaced in lieu of shutdown if repairs to the system are required.

The fuel cell system operations and performance will be continuously monitored to ensure performance and emission commitments are met. If monitoring indicates improper operation, the manufacturer will inspect the system to determine the cause, and the service required to restore the SOFC system to optimal performance. Maintenance activities may include the replacement of air filters, fans, water deionization tanks and gas desulfurization canisters.

The manufacturer’s records indicate that maintenance events typically occur 1-2 times per year, dependent on prevailing operating conditions. Fuel cell stack replacement occurs approximately every five years. There are no impacts to emissions related to maintenance activities.

ADS has received design information for the facility showing the anticipated physical exhaust stack construction for the SOFC unit. A plot plan and process flow diagram of the PDX-62 data center are included in Form AQ102 in Appendix A. The SOFC units will be located outside of existing buildings. The SOFC system is organized into groups of individual fuel cell energy servers (ES). Each ES has a fuel processor (FP), power converter (AC), and several individual power modules (PM). ADS has ordered 77-325 kW ES and 3-300 kW ES. There are two exhaust points for each PM located toward the center of the blocks as shown in Figure 2-2. Total power capacity of the PDX-62 SOFC system is 24.3 MW.

Figure 2-2. Exhaust Locations



3. AIR EMISSION CALCULATION METHODOLOGY

The following section summarizes the sources of emissions, process description, methodology, and emission factors used to estimate air pollutant emissions from the fuel cells.

3.1 Air Pollutant Emissions and Calculation Methodology

3.1.1 Summary of Air Pollutant Emissions

The oxidation of natural gas fuel and oxygen in the SOFC will result in emissions of PM, PM₁₀, PM_{2.5}, SO₂, NO_x, CO, VOC, HAP, and CO₂. A summary of the potential emissions of regulated pollutants from the SOFC unit operation at the PDX-62 facility are shown in Table 3-1.

ADS will remain below current PSELs for criteria pollutants and hazardous air pollutants (HAPs). This application is submitted to modify the current PSEL for GHGs because emission increases are expected to exceed the significant emission rate (SER) for GHGs.

Table 3-1. Project Emissions - SOFC Air Emission Summary

Pollutant	Emission Factor (lb/MW-hr)	Hourly Emission Rate (lb/hr)	Annual Emission Rate (tpy)
PM	0.022	0.53	2.34
PM ₁₀	0.022	0.53	2.34
PM _{2.5}	0.015	0.36	1.60
SO ₂	5.95E-06	1.45E-04	6.33E-04
NO _x	0.0017	0.041	0.18
CO	0.012	0.29	1.28
VOC	0.010	0.24	1.06
GHG	833	20,242	88,660
Total HAP	3.64E-04	0.0088	0.039
Benzene (71-43-2)	1.36E-05	<i>3.30E-04</i>	<i>1.45E-03</i>
Carbon disulfide (75-15-0)	4.80E-05	<i>1.17E-03</i>	<i>5.11E-03</i>
Methanol (67-56-1)	2.27E-04	<i>5.52E-03</i>	<i>2.42E-02</i>
Toluene (108-88-3)	4.43E-05	<i>1.08E-03</i>	<i>4.72E-03</i>
m, p, o-Xylene (1330-20-7)	3.06E-05	<i>7.44E-04</i>	<i>3.26E-03</i>

3.1.2 Emission Calculation Methodology

Project emissions are the total potential emissions from the SOFC installation, based on emission factors provided by the manufacturer specification sheets and summarized in Table 3-1 above. References for individual emission factors utilized for each pollutant are summarized in Section 3.2 Supporting Information, excluding SO₂.

The SO₂ emission factor is calculated based on the expected sulfur content of 0.5 grains sulfur per 100 standard cubic feet (gr S/100 SCF) of pipeline quality natural gas used in the system. Natural gas will be supplied to the fuel cells by local utility. The emission factor shown in Table 3-1 is calculated as follows:

$$SO_2 \text{ Emission Factor } \left(\frac{lb}{MWhr} \right) = \frac{\text{Fuel Consumption } \left(\frac{scf}{hr} \right)}{\text{Rated Power (MW)}} \times \left(\frac{lbmol \text{ NG}}{359 \text{ scf NG}} \right) \times \left(\frac{0.005 \text{ lbmol SO}_2}{10^6 \text{ lbmol NG}} \right) \times \left(\frac{64 \text{ lb SO}_2}{lbmol \text{ SO}_2} \right)$$

Where:

$$\text{Fuel Consumption} = \text{Rated Power} * \text{Heat Rate (6,562 BTU LHV/kW - hr)} / \text{NG LHV (983 BTU/SCF)}$$

$$\text{Rated Power} = 24.3 \text{ MW}$$

Potential emissions of all pollutants are calculated assuming continuous operation of the units at the maximum facility design rate of 24.3 MW. Detailed emissions calculations are included in Appendix B of this application package.

3.2 Supporting Information

The following SOFC supporting documentation is included in Appendix C:

- ▶ PM, PM₁₀, PM_{2.5}
 - Montrose Air Quality Services, LLC; Source Test Report, 2022 Engineering Testing, Bloom Energy, ES-5 “YUMA” Fuel Power Cell and Ambient Air Background, Sunnyvale, California; Document Number: W005AS-12216A-RT-1974; Test Date: January 11, 2022.
- ▶ SO₂
 - Pipeline-quality natural gas fuel sulfur content
- ▶ NO_x, CO, VOCs, and CO₂
 - Bloom Energy, Inc.; *The Bloom Energy Server 5 Data Sheet*; bloomenergy.com; 2022.
- ▶ Hazardous Air Pollutants⁴
 - Montrose Air Quality Services, LLC; *2021 Emissions Tests, Bloom Energy, ES5 fired on Natural Gas*; Document Number: W005AS-006509-RT-1458; Test Date: March 25, 2021.

⁴ The source testing completed identifies seven (7) constituents above the detection limit; benzene, toluene, xylenes, methanol, acetone, carbon disulfide, and 2-butanone (methyl ethyl ketone). ADS and the fuel cell manufacturer have determined that the results identifying acetone, benzene, 2-butanone (methyl ethyl ketone), toluene, and xylenes are questionable, because these components would not typically be found in pipeline quality natural gas and are not byproducts of the SOFC system. Furthermore, these components are all expected to be found in a laboratory setting from the cleaning glassware process. It is posited that the sample was contaminated with these components during analysis phase of the emissions testing; however, emissions for all pollutants are included as a conservative measure.

4. REGULATORY APPLICABILITY

This section describes the applicability of state and federal regulations associated with this project. Only regulations which are new to the permit, adjusted due to the project, or are potentially applicable to the SOFC system are addressed herein. There are no federal New Source Performance Standards (NSPS) or National Emission Standards for Hazardous Air Pollutants (NESHAP) currently applicable to fuel cells.

PDX-62 is not located in the Portland Air Quality Management Area (AQMA), Medford AQMA, Salem-Keizer Area Transportation Study (SKATS), or any of Oregon's maintenance areas for air pollution defined in OAR 340-204-0010. There are no requirements for areas with unique air quality needs associated with this facility.

4.1 OAR 340-215: Oregon Greenhouse Gas Reporting Program

The requirements for the Oregon Greenhouse Gas Reporting Program are codified in Oregon Administrative Rules Chapter 340, Division 215, which establishes the requirements associated with GHG registration and reporting for operators of certain facilities that emit greenhouse gases, fuel suppliers, and electricity suppliers.

The PDX-62 facility is currently required to complete registration and reporting for GHG under the Oregon GHG Reporting Program if the facility emits more than 2,500 metric tons (MT) of GHG in a year. It is expected actual emissions of GHG from the SOFC system will be greater than 2,500 MT carbon dioxide equivalent per year (CO₂e/yr), thereby triggering registration under this program.⁵ However, in review of the federal regulations (40 CFR 98), there is no subpart applicable to fuel cells. The determination of applicability to the Federal Subparts is further described in Section 4.10.

The fuel cells do not combust fuel (Subpart C-Fuel Combustion), the facility is not subject to acid rain program (Subpart D-Electricity Generation), and the fuel cells will only supply hydrogen and electricity to the ADS site (Subpart P-Hydrogen Production and Subpart DD-Electrical Transmission). As such, the facility will only be required to report emissions associated with diesel fuel combustion, since the fuel cells do not have an applicable federal subpart, pursuant to 340-215-0105(1).

4.2 OAR 340-216: Air Contaminant Discharge Permitting

The PDX-62 data center operates under a Standard ACDP from Oregon DEQ and is proposing to increase the PSEL for GHG emissions. The current facility PSEL for GHG emissions is the generic PSEL of 74,000 tpy. The site wide potential non-emergency emissions for GHG is 3,395 tpy and the GHG associated with this project is 88,600 tpy. The requested increase is above the PSEL in an amount less than the 75,000 tpy SER established by Oregon DEQ for GHGs.⁶

The summary of the current facility emissions and PSEL increases from SOFC operation at the PDX-62 data center are shown in Table 4-1. The current facility emergency and non-emergency PTE emissions are referenced from the September 2021 security generator Notice of Construction Application submitted to Oregon DEQ.

⁵ Per OAR 340-215-0030(2)(b)

⁶ Per OAR 340-200-0020(161)(a).

Table 4-1. PDX-62 Potential Emissions Summary and PSEL Comparison

Pollutant	Potential Emissions			Plant Site Emission Limits (PSEL)		
	Current Facility Wide Non-Emergency⁶	Current Facility Wide Non-Emergency and Emergency⁶	SOFC Project Emissions	Current PSEL	PSEL Increase	Proposed PSEL
	(tpy)	(tpy)	(tpy)	(tpy)	(tpy)	(tpy)
PM	1.12	2.85	2.34	24	-	24
PM ₁₀	1.12	2.85	2.34	14	-	14
PM _{2.5}	1.12	2.85	1.60	9	-	9
SO ₂	0.030	0.083	6.33E-04	39	-	N/A
NO _x	39.00	98.93	0.18	39	-	39
CO	13.27	33.63	1.28	99	-	99
VOC	3.76	9.54	1.06	39	-	39
GHG (CO ₂ e)	3,395	8,597	88,660	74,000	18,054	92,054

The proposed changes qualify as a Type 3 modification and require a permit modification application be submitted to Oregon DEQ.⁷ This application includes the appropriate modification forms and supporting documentation in Appendix A. The required ACDP modification of increasing the GHG PSEL is expected to be classified as a moderate technical modification of the ACDP since the fuel cells are expected to have a simple compliance method.⁸ A corresponding fee of \$9,000 has been submitted to Oregon DEQ.⁹

In accordance with OAR 340-216-0040(3), this application details the requested changes to the permit in Section 5 and new applicable requirements in Section 4.

The following Oregon DEQ forms are included in Appendix A:

- ▶ Administrative Information (AQ101);
- ▶ Facility Description (AQ102);
- ▶ Miscellaneous Processes and Devices (AQ230);
- ▶ Plant Site Emissions Detail (AQ402);
- ▶ Hazardous Air Pollutant Emission Details (AQ403); and
- ▶ Land Use Compatibility Statement.

4.3 OAR 340-218: Title V Operating Program

The requirements for the 40 CFR Part 70 (Title V) Operating Permit program are codified in Oregon Administrative Rule (OAR) 340 division 218. Per OAR 340-218-0020, division 218 applies to any of the following:

- ▶ Any major source;

⁷ Per OAR 340-210-0225(3).

⁸ This classification was confirmed during an initial meeting with Oregon DEQ on May 18, 2022.

⁹ Per OAR 340-216-0030(3).

- ▶ Any source, including an area source, subject to a standard, limitation, or other requirement under section 111 of the FCAA;
- ▶ Any source, including an area source, subject to a standard or other requirement under section 112 of the FCAA, except that a source is not required to obtain a permit solely because it is subject to regulations or requirements under section 112(r) of the FCAA;
- ▶ Any affected source under Title IV; and,
- ▶ Any source in a source category designated by the EQC under this rule.

The definition of a “major source” under OAR 340-200-0020(91) is,

“(a) Except as provided in subsection (b) of this section, means a source that emits, or has the potential to emit, any regulated air pollutant at a Significant Emission Rate. The fugitive emissions and insignificant activity emissions of a stationary source are considered in determining whether it is a major source. Potential to emit calculations must include emission increases due to a new or modified source and may include emission decreases.”

PDX-62 does not emit any air pollutant regulated under Title V above the associated SER defined in OAR 340-200-0020, Table 5-1, except for GHG emissions of CO₂e. OAR 340-200-0020(91)(b)(B) states that major stationary source of regulated pollutants, are sources that directly emits or have the potential to emit 100 tons per year or more of any regulated pollutant, *except greenhouse gases*. Therefore, PDX-62 does not meet the definition of a major source as described in OAR 340-200-0020(91).

The PDX-62 data center is a synthetic minor source, or a source which would otherwise be a major source but has established limits in its an ACDP to ensure emissions remain below the emission level that cause it to be a major source. ADS fuel cell operation will not cause an increase the currently permitted Potential to Emit (PTE) above the major source emission rate thresholds.

Table 4-2 shows the currently permitted PDX-62 facility-wide PTE, as well as the post project PTE for the site.

Table 4-2. PDX-62 Synthetic Minor Source Determination

Pollutant	Current Facility Wide Non-Emergency and Emergency PTE	SOFC Project Emissions	Post Project Facility Wide Non-Emergency and Emergency PTE
	(tpy)	(tpy)	(tpy)
PM	2.85	2.34	5.19
PM ₁₀	2.85	2.34	5.19
PM _{2.5}	2.85	1.60	4.44
SO ₂	0.083	6.33E-04	0.084
NO _x	98.93	0.18	99.11
CO	33.63	1.28	34.91
VOC	9.54	1.06	10.60
GHG (CO ₂ e)	8,597	88,660	97,257
Total HAP	0.24	0.039	0.28

Pursuant to 340-218-0020(8), categorically and aggregate insignificant activities as defined in OAR 340-200-0020(23) have been considered in the determination facility designation as a synthetic minor source. Categorically insignificant activities at the PDX-62 data center include but are not limited to the following:

- ▶ Belly tanks storing diesel at ambient pressure and temperature
- ▶ Evaporative and tailpipe emissions from on-site motor vehicle operation,
- ▶ Office, food service, and personal care activities,
- ▶ Janitorial and groundskeeping activities;
- ▶ Air cooling or ventilating equipment not designed to remove air contaminants generated by or released from associated equipment;
- ▶ Accidental fires and fire suppression; and
- ▶ Electrical charging stations.

The total emissions from insignificant activities are not expected to cause the facility to exceed any associated major source emission thresholds.

Furthermore, the PDX-62 facility is not subject to a standard, limitation, or other requirement under section 111 or 112 of the Federal Clean Air Act (FCAA). The PDX-62 facility is not an affected source under Title IV and is not a source category identified in OAR 340-218-0020.

None of the source types listed above and defined in OAR 340-218-0020(1) describe the PDX-62 facility. As such, division 218 and the Oregon Title V Operating Permit program is not applicable to the PDX-62 facility.

4.4 OAR 340-222: Stationary Source Plant Site Emission Limits

The summary of project emissions from SOFC operation at the PDX-62 data center is shown in Table 4-2, including a comparison of the current and requested facility Plant Site Emission Limits (PSEL).

The current PSEL and requested PSEL are the same for all pollutants except GHG. Excluding GHG, the proposed PSELs for all pollutants are equal to the Generic PSEL in accordance with OAR 340-222-0040(2). The facility requests to increase GHG PSEL by 18,054 tpy for the facility wide potential to emit for all non-emergency use.

SO₂ is included in Table 4-3 because there is an established PSEL in the current ACDP. However, OAR 340-222-0020(3)(a) states that PSELs are not required for regulated pollutants that will be emitted at less than the de minimis emission level listed in OAR 340-200-0020. Total SO₂ from the facility will be less than the de minimis emission level established; therefore, ADS requests to remove the current PSEL for SO₂.

Demonstration of compliance with the PSELs in this application for the SOFC system will be completed by monitoring the total power output of all fuel cells and ensure there is no exceedance of the 24.3 MW requested.

Table 4-3. PDX-62 Facility Total Emissions Summary and PSEL Comparison

Pollutant	Current PSEL (tpy)	Current Facility Wide PTE (tpy)		Project Emissions (tpy)	Project Emissions Increase above PSEL (tpy)	Requested PSEL (tpy)
		Non-Emergency	Non-Emergency and Emergency			
PM	24	1.12	2.85	2.34	-	24
PM ₁₀	14	1.12	2.85	2.34	-	14
PM _{2.5}	9	1.12	2.85	1.60	-	9
SO ₂	39	0.030	0.083	6.33E-04	-	N/A
NO _x	39	39.00	98.93	0.18	-	39
CO	99	13.27	33.63	1.28	-	99
VOC	39	3.76	9.54	1.06	-	39
GHG	74,000	3,395	8,597	88,660	18,054	92,054

4.5 OAR 340-224: Major New Source Review

Per OAR 340-224-0010(1) the Major New Source Review (NSR) requirements of division 224 are applicable to the owner or operator of a source undertaking one of the following actions in an attainment area:

- ▶ Construction of a new federal major source;
- ▶ Major modification at an existing federal major source; or,
- ▶ Major modification at an existing source that will become a federal major source because emissions of a regulated pollutant are increased to the federal major source level or more.

The PDX-62 facility currently is not and has never been subject to the Major NSR program as emissions of regulated pollutants are below the applicable thresholds of 250 tpy of all attainment area pollutants. As such, the facility is not subject to the requirements of the Major NSR program.

4.6 OAR 340-224: State New Source Review

Pursuant to OAR 340-224-0010(2), the State NSR requirements of division 224 apply to an owner or operator of a source undertaking one of the following actions in an attainment area that is not subject to the requirements of Major NSR:

- ▶ Construction of a new source that will have emissions of a regulated pollutant equal to or greater than the Significant Emission Rate (SER), as defined in OAR 340-200-0020, as displayed in Table 5-1; or
- ▶ Increasing emissions of a regulated pollutant to an amount that is equal to or greater than the SER over the netting basis.

Excluding GHG emissions of total Carbon Dioxide equivalent (CO_{2e}), the facility does not emit any pollutant regulated under the State NSR rules above the SER limits, as defined in OAR 340-200-0020. The facility requests to increase CO_{2e} emissions by 88,660 tpy, which is over the greenhouse gas (GHG) SER limit; however, per OAR 340-224-0010(2)(c), "GHGs are not subject to State NSR." Therefore, PDX-62 will not be subject to the requirements of the State NSR program with this action.

4.7 OAR 340-226-0130: General Emission Standards TACT

The requirements for Oregon's General Emission Standards, Typically Achievable Control Technology (TACT), are codified in OAR 340-226-0130. These regulations define the standards for the establishment of emission limits for existing sources based on the typical emission level achieved by emissions units similar in

type and size. Under this rule, a new or modified emissions unit must meet TACT for new or modified sources if the emissions unit would have emissions of any criteria pollutant equal to or greater than 1 ton per year.¹⁰ The emissions provided with this application indicate that the PDX-62 SOFC system will have a potential emission rate greater than 1 ton per year for PM, PM₁₀, PM_{2.5}, CO, and VOC.

Many states have explicit fuel cell exemptions from air permitting and therefore do not have established emission limits for comparison.¹¹ The SOFC manufacturer authorized a facility located in Delaware under an air permit with Delaware Department of Natural Resources and Environmental Control (DNREC). The facility, the Red Lion 24.9 MW Fuel Cell Electric Generation Plant, is authorized under DNREC Permit: APC-2019/0031-OPERATION, which establishes that there are no emission control systems associated with the installation.

The established emission limits for the Delaware 24.9 MW SOFC system are shown in Table 4-4 for CO and VOC to demonstrate that the emissions requested for PDX-62 SOFC operation are typical of the emission level achieved by similar SOFC systems. The permit does not include particulate matter emissions limits; however, it does limit the emission of visible air contaminants to twenty percent opacity, consistent with requirements in the state of Oregon.¹² This opacity limitation is achievable with no emissions control systems installed.

Table 4-4. SOFC TACT - PDX-62 Synthetic Minor Source Determination¹³

Pollutant	Oregon PDX-62 24.3 MW SOFC Requested Emissions	Delaware Red Lion 24.9 MW SOFC Permitted Emissions
	(tpy)	(tpy)
PM	2.34	-
PM ₁₀	2.34	-
PM _{2.5}	1.60	-
CO	1.28	3.71
VOC	1.06	1.73

The SOFC system will be operated in accordance with manufacturer's recommendations and guidance. Furthermore, the fuel cell technology is recertified by the California Air Resources Board (CARB) every five years, based on source test results for all criteria pollutants, including PM, PM₁₀, PM_{2.5}, CO, and VOC. The current CARB Certification is included in Appendix D.

A review of the Reasonably Available Control Technology (RACT) / Best Available Control Technology (BACT) / Lowest Achievable Emission Reduction (LAER) Clearinghouse (RBLC) data was completed in order to determine if there are any relevant and current retrofit controls available. The RBLC was queried for the previous ten years, and no existing control technologies associated with fuel cells or SOFC systems was

¹⁰ OAR 340-226-0130(2)(c)(A)

¹¹ New York [6 CRR-NY 201-3.2](#), SCAQMD [Rule 219\(b\)\(5\)](#), and Massachusetts [301 CMR 7.03\(18\)](#).

¹² OAR 340-208-0110(2)(a) and (4)

¹³ DNREC Permit: APC-2019/0031-OPERATION; Diamond State Electric Generation Partners, LLC (Bloom Energy); Red Lion 24.9 MW Fuel Cell Electric Generation Plant; December 20, 2019

identified. Additionally, it is not anticipated that the installation of additional physical control would be technically practical because the SOFC exhaust vents do not allow for easy containment or addition of control equipment. Emissions may be reduced by use of pure hydrogen instead of natural gas as a fuel source. However, there is no infrastructure available to supply hydrogen to the PDX-62 site.

Based on this assessment, ADS has determined that proper operation and maintenance represents TACT for SOFC systems, as requested in this application, and that further emission control is not necessary to ensure that the source is in compliance with applicable requirements or protect public health or welfare or the environment.

4.8 OAR 340-245: Cleaner Air Oregon

The PDX-62 facility is an existing source under the Cleaner Air Oregon (CAO) program as the facility commenced construction prior to November 16, 2018.¹⁴ As an existing source, the facility is required to provide information related to this rule if requested by Oregon DEQ in writing, or if triggering New Source Review under OAR 340-224-0010(1) or (2).¹⁵ As established, this project does not require New Source Review, therefore the facility has no current requirements under this regulation for permitting.

4.9 OAR 340-271: Oregon Climate Protection Program

The requirements for the Oregon Climate Protection Program are codified in OAR 350-271 and are intended to establish the rules and requirements for select air contamination sources that emit GHGs or that cause GHGs to be emitted.

Specifically, these regulations apply to fuel supplier and stationary sources that meet the following definitions:

- ▶ OAR 340-271-0020(15) - "covered fuel supplier" means an air contamination source that is either: (a) A fuel supplier or in-state producer as described in OAR 340-271-0110(3); or (b) A local distribution company as described in OAR 340-271-0110(4).
- ▶ OAR 340-271-0020(16) - "covered stationary source" means an air contamination source described in OAR 340-271-0110(5).
 - 340-270-0110(5)(a) describes a covered stationary source as one with an ACDP or Title V permit and annual or potential covered emissions greater than 25,000 MT CO₂e/calendar year.

Covered emissions under this rule include the following, pursuant to OAR 340-271-0110(5)(b):

- ▶ Covered emissions include emissions of anthropogenic greenhouse gases in metric tons of CO₂e that are from either or both processes or the combustion of solid or gaseous fuels, including emissions from combustion for both energy production and processes.
- ▶ Covered emissions do not include:
 - Emissions that are from the combustion of biomass-derived fuels;
 - Biogenic CO₂ emissions from solid fuels;
 - Emissions that are from the combustion of liquid fuels or propane; or
 - Emissions from natural gas, compressed natural gas, or liquefied natural gas used on-site that was delivered by a local distribution company.

¹⁴ OAR 340-245-0020(20).

¹⁵ OAR 340-245-0050(1)(a) and (b).

The PDX-62 facility will only use the SOFC generated power onsite and does not meet the definition of a covered fuel supplier or stationary source. Furthermore, the site will utilize only natural gas delivered by a local distribution company in the SOFC system; therefore, the requirements of OAR 340-271 do not apply.

4.10 40 CFR 98: Federal Greenhouse Gas Reporting Program

The federal Greenhouse Gas Reporting Program (GHGRP) requires reporting of greenhouse gas (GHG) data and other relevant information from certain large GHG emission sources, fuel and industrial gas suppliers, and CO₂ injection sites in the United States. Regulations for the GHGRP are included in Title 40 of the Code of Federal Regulations (CFR), Part 98. Subparts of this Part which potentially apply to the fuel cells are as follows.

- ▶ Subpart C – Stationary Fuel Combustion Sources
- ▶ Subpart D – Electricity Generation
- ▶ Subpart P – Hydrogen Production
- ▶ Subpart DD - Electrical Transmission and Distribution Equipment

A discussion of each Subpart is included in this section.

4.10.1 Subpart C – Stationary Fuel Combustion Sources

40 CFR §98.30 defines stationary fuel combustion sources as devices that combust solid, liquid, or gaseous fuel, for the purposes of producing electricity, generating steam, or providing useful heat or energy for industrial, commercial, or institutional use, or reducing the volume of waste by removing combustible matter. Sources regulated under this Subpart include, but are not limited to, boilers, simple and combined-cycle combustion turbines, engines, incinerators, and process heaters.

The Bloom Energy SOFC units utilizes a reactant in the form of hydrogen (H₂), derived primarily from natural gas, and an oxidant in the form of oxygen (O₂), derived from the ambient air. In the system, ambient air passes over the cathode where it is catalyzed into oxygen ions (O²⁻), which then interact with hydrogen passing over the fuel cell anode. The resulting chemical reaction between these molecules leaves 2 free electrons that create a charge that is converted into electricity.

Power generation in SFCO systems does not utilize any form of combustion or fuel or thermal processes; therefore, the requirements of 40 CFR 98, Subpart C do not apply to these units.

4.10.2 Subpart D – Electricity Generation

The electricity generation source category of the GHGRP includes electricity generating units that are subject to the requirements of the Acid Rain Program and any other electricity generating units that are required to monitor and report to EPA CO₂ emissions year-round according to 40 CFR part 75.

The PDX-62 facility is not subject to the requirements of the Acid Rain Program pursuant to 40 CFR 72.6(b)(8), because the facility is non-utility unit as defined this section. A utility is defined as any person that sells electricity.¹⁶ Electricity generated in the PDX-62 SOFC system will be used exclusively onsite and will not be sold or transmitted to any other location.

Electricity generating units are defined in 40 CFR part 75 as any combination of physically connected generator(s), reactor(s), boiler(s), combustion turbine(s), or other prime mover(s) operated together to

¹⁶ 40 CFR 72.2 "Utility"

produce electric power. The SOFC units are not considered prime movers because they do not create mechanical force in operation. There is no mechanical process associated with the fuel cells; as such, the requirements of this Subpart do not apply.

4.10.3 Subpart P – Hydrogen Production

The hydrogen production source category consists of facilities that produce hydrogen gas sold as a product to other entities, comprising of process units that produce hydrogen by reforming, gasification, oxidation, reaction, or other transformations of feedstocks.

Hydrogen generated in the PDX-62 SOFC system will be used exclusively in the SOFC system and will not be sold or transmitted to any other device or location. The requirements of Subpart P do not apply to this facility.

4.10.4 Subpart DD - Electrical Transmission and Distribution Equipment

Pursuant to 40 CFR §98.300, electrical transmission and distribution equipment under this Subpart includes equipment insulated with or containing SF₆ or PFCs that is linked through electric power transmission or distribution lines and functions as an integrated unit, that is owned, serviced, or maintained by a single electric power transmission or distribution entity (or multiple entities with a common owner), and that is located between: (1) the point(s) at which electric energy is obtained from an electricity generating unit or a different electric power transmission or distribution entity that does not have a common owner, and (2) the point(s) at which any customer or another electric power transmission or distribution entity that does not have a common owner receives the electric energy.

Electricity generated in the PDX-62 SOFC system will be used exclusively onsite and will not be sold or transmitted to any other location. The requirements of Subpart DD do not apply to this facility.

5. PROPOSED PERMIT CHANGES

ADS is requesting the following changes to ACDP No. 25-0029-ST-01.

1. Update Section 4.1 to remove SO₂ PSEL and update GHG PSEL:

Table 5-1. Condition 4.1 Updated PSEL Table

Pollutant	Limit	Units
PM	24	tons per year
PM ₁₀	14	tons per year
PM _{2.5}	9	tons per year
NO _x	39	tons per year
CO	99	tons per year
VOC	39	tons per year
GHG	92,054	tons per year

2. Update Section 5.0 to include Monitoring Requirements and PSEL Compliance Monitoring for SOFC.
 - a. Suggest monitoring the aggregate power output of the SOFC.
 - b. PSEL Compliance would follow the current method identified in Condition 5.2 equation with the Process/Production Table detailed below.
 - c. This will also require updates to Conditions 7.1 (Recordkeeping of Operation and Maintenance) and 8.3 (Annual Report)
3. Update Condition 8.4 to detail specifics of required reported emissions discussed in Section 4.1.
4. The addition of 24.3 MW of total SOFC capacity, including description of the devices and processes in Section 13.0 for SOFC operation:

Table 5-2. Proposed Updates to Section 13.0 Emission Factors

Emission Device	Pollutant	Emission Factor	EF Units	EF Reference
24.3 MW Solid Oxide Fuel Cell (SOFC) energy generation (SOFC-01)	PM	0.022	(lbs/MW-hr)	Manufacturer's Specifications and Manufacturer's Source Test Data
	PM ₁₀	0.022		
	PM _{2.5}	0.015		
	NO _x	0.0017		
	CO	0.012		
	VOC	0.01		
	CO ₂	833		

5. Add Process/Production Records Table:

Table 5-3. Process/Production Records

Emission Device	Process or Production Parameter	Units of Measure	Frequency	Regulatory Purpose
Solid Oxide Fuel Cell (SOFC)	Power Output	MW	Monthly	PSEL Compliance
Emergency Generators and Fuel Pumps	Diesel Fuel Use during Non-emergency Use	Gallons	Monthly	PSEL Compliance
Emergency Generators and Fuel Pumps	Diesel Fuel Use during Emergency Use	Gallons	Monthly	Synthetic Minor Status
Emergency Generators and Fuel Pumps	Hours of Operation for Non-Emergency Use	Hours	Monthly	NSPS IIII Compliance
Emergency Generators and Fuel Pumps	Hours of Operation for Emergency Use	Hours	Monthly	NSPS IIII Compliance

APPENDIX A. APPLICATION FORMS

This section includes the following Oregon DEQ application forms:

- ▶ Administrative Information (AQ101);
- ▶ Facility Description (AQ102);
- ▶ Miscellaneous Processes and Devices (AQ230);
- ▶ Plant Site Emissions Detail (AQ402);
- ▶ Hazardous Air Pollutant Emission Details (AQ403); and
- ▶ Land Use Compatibility Statement.



Form AQ101 - Answer Sheet

DEQ USE ONLY	
Permit Number:	Type of Application:
Application No:	RNW ____ MOD ____ NEW ____
Date Received :	
Regional Office: ER - AQ Permit Coordinator	Check No. Amount \$

1. Company			2. Facility Location		
Legal Name: Amazon Data Services, Inc.			Name: PDX62		
Mailing Address: PO Box 80711			Street Address: 75300 Lewis and Clark DR.		
City: Seattle	State: WA	Zip Code: 98108	City: Boardman	County: Morrow	Zip Code: 97818
Number of employees (Corporate):		N/A	Number of employees (Facility):		120
3. Industrial Classification Code(s)			4. Other DEQ Permits		
Primary SIC and NAICS: 7374 (SIC)			25-0029-ST-01; NC#31947; NC#33690; NC#32856		
Secondary SIC and NAICS: N/A			5. LUCS: ☐ New facility ☒ Modified facility Tax Lot #: 04N26E07 - 103		

6. Permit Action:

- ☐ Short Term Activity ACDP
☐ New Simple ACDP with short-term NAAQS analysis
☐ New Construction ACDP with short-term NAAQS analysis
☐ New Standard ACDP with short-term NAAQS analysis
☐ New or modified Standard ACDP (PSD/NSR) with short-term NAAQS analysis
☐ Renewal of an existing permit without changes (include form AQ403 for Standard ACDPs)
☐ Renewal of an existing permit with changes (include any other necessary forms and form AQ403 for Standard ACDPs)
☒ Modification of existing permit

7. Signature

I hereby apply for permission to discharge air contaminants in the State of Oregon, as stated or described in this application, and certify that the information contained in this application and the schedules and exhibits appended hereto, are true and correct to the best of my knowledge and belief.

Steven Meyers

Name of official (Printed or Typed)

Authorized Representative

Title of official and phone number

DocuSigned by:

Steven Meyers

92502CB89512462

Signature of official

June 14, 2022

Date

Fee Information

(Make check payable to DEQ)

Note: The initial application fees and annual fees specified below (OAR 340-216-8020, Table 2, Parts 1, 2 and 3) are only required for initial permit applications. These fees are not required for an application to renew or modify an existing permit. The appropriate specific activity fee(s) specified below (OAR 340-216-8020, Table 2, and Part 4) applies to permit modifications or may be in addition to initial permit application fees.

OAR 340-216-8020, Table 2, Part 1 – Initial Permitting Application Fees:		
Short Term Activity ACDP	☐	\$4,500.00
Simple ACDP	☐	\$9,000.00
Construction ACDP	☐	\$14,400.00
Standard ACDP	☐	\$18,000.00
Standard ACDP (Major NSR or Type A State NSR)	☐	\$63,000.00
OAR 340-216-8020, Table 2, Part 2 – Annual Fees:		
Simple ACDP – Low fee class	☐	\$3,917.00
Simple ACDP – High fee class	☐	\$7,834.00
Standard ACDP	☐	\$15,759.00
OAR 340-216-8020, Table 2, Part 3 – Cleaner Air Oregon Annual Fees:		
Simple ACDP - Low fee class	☐	\$806.00
Simple ACDP - High fee class	☐	\$1,612.00
Standard ACDP	☐	\$3,225.00
OAR 340-216-8020, Table 2, Part 4 – Specific Activity Fees:		
Non-Technical Permit Modification	☐	\$432.00
Basic Technical Permit Modification	☐	\$540.00
Simple Technical Permit Modification	☐	\$1,800.00
Moderate Technical Permit Modification	☒	\$9,000.00
Complex Technical Permit Modification	☐	\$18,000.00
Major NSR or type A State NSR Permit Modification	☐	\$63,000.00
Modeling review (outside Major NSR or type A State NSR)	☐	\$9,000.00
Public Hearing at Source's Request	☐	\$3,600.00
State MACT determination	☐	\$9,000.00
Compliance Order Monitoring	☐	\$180.00/month
Total Fees:		\$ 9,000.00

1. Company Information:

Legal Name: Amazon Data Services, Inc.	Other company name (if different than legal name):
---	--

2. Site Contact Person:

(A person who deals with DEQ staff about equipment problems.)

Name: Shannon Khounnala	Telephone number: 509-619-8338	Fax:
Title: Regional Environmental Engineer	Email address: khounnal@amazon.com	
Mailing address: PO Box 80711	City, State, Zip Code Seattle, WA 98108	

3. Facility Contact Person:

(If other than the site contact person, a person involved with all environmental issues at the facility although they may be housed at a different site.)

Name: Shannon Khounnala	Telephone number: 509-619-8338	Fax:
Title: Regional Environmental Engineer	Email address: khounnal@amazon.com	
Mailing address: PO Box 80711	City, State, Zip Code Seattle, WA 98108	

4. Mailing Contact Person:

(If other than the site contact person, a person to whom the company would like all agency communications directed.)

Name: Environmental	Telephone number:	Fax:
Title:	Email address:	
Mailing address: PO Box 80711	City, State, Zip Code Seattle, WA 98108	

5. Invoice Contact Person:

(If other than the site contact person, a contact to which invoices and communications related to resolving invoice questions can be directed.)

Name: Jason Bowker	Telephone number: 541-303-2380	Fax:
Title: Sr. Air Permitting Engineer	Email address: jbowker@amazon.com	
Mailing address: PO Box 80711	City, State, Zip Code Seattle, WA 98108	



Submit TWO copies of the completed application to the appropriate address below.

New or Modified Permits (include fees)

Oregon Department of Environmental Quality
Financial Services – Revenue Section
700 NE Multnomah St., Suite 600
Portland, OR 97232-4100

Permit Renewals (no fees)

Oregon Department of Environmental Quality
Eastern Region, Air Quality,
475 NE Bellevue Dr., Suite 110
Bend, OR 97701-7415



Facility Description

Form AQ102 Instructions

Instructions

1. Provide a text description of the facility processes. In describing the facility and in preparing the permit application, the applicant should always remember that the permit should be written to cover the facility as it will operate for the future permit term. A permit term is five or ten years depending on the type of permit issued. Providing information on future operations now may prevent the need for the additional cost of permit modifications in the future. The applicant should provide the information requested below.
 - A description of the current processes that emit air pollutants;
 - The fuels used and products produced in these processes;
 - If this application is for a permit modification, a discussion of the proposed modification;
 - If this application is for a renewed ACDP, a description of any anticipated modifications to the facility's existing processes during the pending permit term that the ACDP will need to address; and
 - If this application is for an initial or renewed ACDP, a description of any anticipated construction at the facility during the pending permit term that the ACDP will need to address.
2. Attach a plot plan showing the location of all stacks and vents through which regulated pollutants are released to the atmosphere.
3. Attach a process flow diagram which shows the air pollutant emitting processes at the facility. The applicant should ask the DEQ permit writer about the level of detail that is required. The diagram should illustrate the following:
 - All regulated air pollutant-emitting devices and processes at the facility, labeled with the same identification numbers that the applicant assigned them in Form Series AQ200.
 - Flow routes of contaminated air from processes to emission control equipment and emission points.
 - All air pollution control devices at the facility, labeled with the same identification numbers that the applicant assigned them in Form Series AQ300.
 - The location of all stacks and vents through which regulated pollutants are released to the atmosphere.
 - Any materials handling activities that emit regulated pollutants (e.g., loading crushed rock, storage piles, etc.) not addressed in a Device/Process Form (series AQ200).
 - Any fuel storage and piping systems on the facility property.
4. Attach a city map or drawing showing the facility location, property lines and its relation to nearby (i.e., within 1 mile) sensitive receptors such as residential areas, hospitals, schools, etc. If the facility is located in a rural area, the applicant should note distances on approaching roads and also mark the location of landmarks.



State of Oregon
Department of
Environmental
Quality

Facility Description

Form AQ102
Answer Sheet

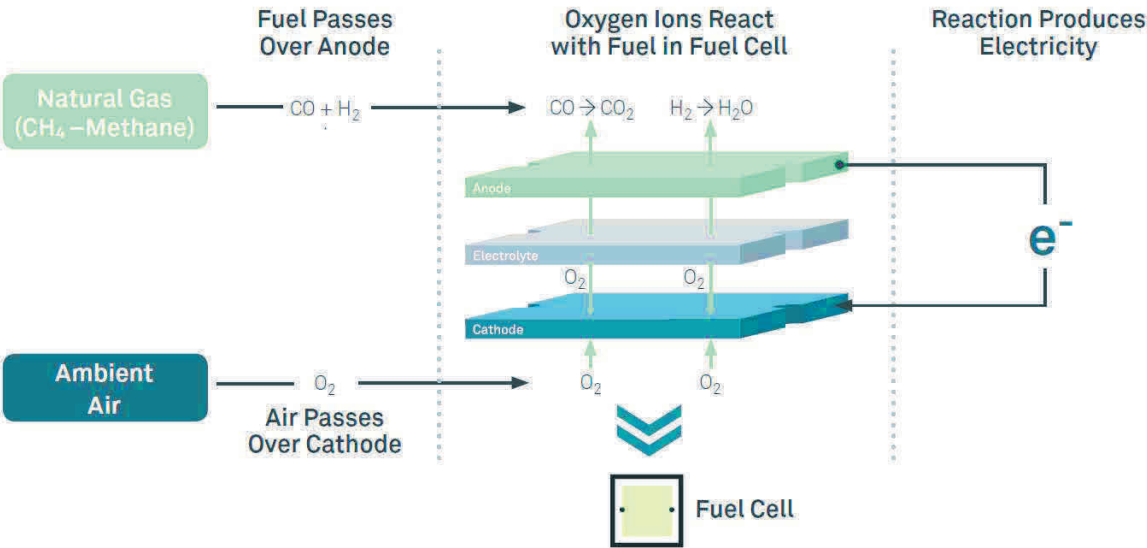
Facility Name: PDX62 Permit Number: 25-0029-ST-01

1. Description of facility and processes:

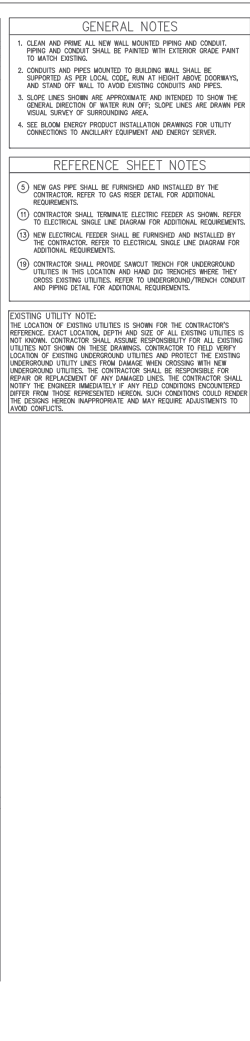
The facility houses computer systems and associated components, such as telecommunications and data storage systems. Equipment at the facility includes security systems, data communications equipment, environmental controls, backup emergency power supplies (generators), and emergency fire pumps. The principal use of the facility is the storage, management, and dissemination of electronic data. A total of 108 emergency generators and two (2) fire pumps are currently approved for operation at the facility.

Solid Oxide Fuel Cells (SOFC) generate power by harnessing an electrochemical reaction between hydrogen from natural gas fuel and oxygen in the ambient air. The generated electricity at PDX-62 will be used as a primary power source to reduce the burden of site operation on publicly available power and ensure reliability of the system. The SOFC system is designed for a capacity of 24.99 MW. The system is expected to run continuously at this capacity. There is no increase or change in emission rates anticipated due to maintenance of the equipment, as components of the system will be replaced instead of shutdown during these activities.

2. Attach plot plan.
3. Attach process flow diagram.
4. Attach a city map or drawing showing the facility location.



Bluemenergy		
4353 N. FIRST STREET SAN JOSE, CA 95134 PROPRIETARY AND CONFIDENTIAL		
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CUSTOMER SITE		
AMAZON WEB SERVICE PDX062.Z 75282 LEWIS AND CLARK DR, BOARDMAN, OR, 97818		
		
REVISION HISTORY		
REV	REVISION DESCRIPTION	DATE
-	INITIAL RELEASE	05/17/2022
DESIGNED BY	REVIEWED BY	
DRAWN BY	APPROVED BY	
LAYNOUSE		
SHEET TITLE		
GENERAL CONSTRUCTION NOTES		
DRAWING NUMBER	60.2	
BLOOM DOCUMENT		
DOC-1015081		
THIS DRAWING IS 24" x 36" AT FULL SIZE		
SHEET 02 OF 26		

[illegible]

Area Map





State of Oregon
Department of
Environmental
Quality

MISCELLANEOUS PROCESS OR DEVICE

FORM AQ230
ANSWER SHEET

Facility Name: PDX62

Permit Number: 25-0029-ST-01

Process Information

1. ID Number	SOFC1
2. Descriptive name	Solid Oxide Fuel Cells
3. Existing or future?	Future
4. Date commenced	2/16/2023
5. Date installed/completed	TBD

6. Description of process:

Solid Oxide Fuel Cells (SOFC) generate power by harnessing an electrochemical reaction between natural gas fuel and oxygen ions in the ambient air. The SOFC system is designed for a capacity of 24.3 MW.

Operating Schedule

7. Seasonal or year-round?	Year-round	v
8. Batch or continuous operation?	Continuous	v
9. Projected maximum hours/day	24	
10. Projected maximum hours/year	8,760	

11. Process/device capacity:	Short term capacity		Annual usage		
	Raw materials	Amount	Units	Amount	Units
Natural Gas	166,820	scf/hr	1,461	MMscf/yr	

Products				
Electricity	24.3	MWh (Aggregate)	212868	MW/yr (Aggregate)

12. Control devices(s) (yes/no)

No

If yes, provide the ID number and complete and attached the applicable series AQ300 form(s).



PLANT SITE EMISSIONS DETAIL SHEET
CURRENT/FUTURE OPERATIONS

FORM AQ402
ANSWER SHEET

State of Oregon
 Department of
 Environmental
 Quality

Facility Name:

PDX62

Permit Number:

25-0029-ST-01

Table 1

1. Emissions Point	Production Rates		4. Pollutant	Emissions Factors			Emissions	
	2. Short-term (Specify units)	3. Annual (Specify units)		5. Short-term	6. Long-term	7. Reference(s)	8. Short-term (Specify units)	9. Annual (tons/year)
SOFC01-168	24.3 MWh	212868 MW/yr	NOx	0.0017 lb/MWh	0.0017 lb/MWh	See emission calculations	0.041 lb/hr	0.2
SOFC01-168	24.3 MWh	212868 MW/yr	CO	0.012 lb/MWh	0.012 lb/MWh	See emission calculations	0.29 lb/hr	1.3
SOFC01-168	24.3 MWh	212868 MW/yr	VOC	0.010 lb/MWh	0.010 lb/MWh	See emission calculations	0.24 lb/hr	1.1
SOFC01-168	24.3 MWh	212868 MW/yr	SO2	5.95E-06 lb/MWh	5.95E-06 lb/MWh	See emission calculations	1.45E-04 lb/hr	0.0
SOFC01-168	24.3 MWh	212868 MW/yr	PM	0.022 lb/MWh	0.022 lb/MWh	See emission calculations	0.53 lb/hr	2.3
SOFC01-168	24.3 MWh	212868 MW/yr	PM10	0.022 lb/MWh	0.022 lb/MWh	See emission calculations	0.53 lb/hr	2.3
SOFC01-168	24.3 MWh	212868 MW/yr	PM2.5	0.015 lb/MWh	0.015 lb/MWh	See emission calculations	0.36 lb/hr	1.6
SOFC01-168	24.3 MWh	212868 MW/yr	CO2e	833	833	See emission calculations	20,242 lb/hr	88,660.0
Example	200 tons of rock/hr	400,000 tons	PM	0.04 lb/ton	0.04 lb/ton	DEQ	8.0 lb/hr	8.0

FORM AQ402
ANSWER SHEET

State of Oregon
Department of
Environmental
Quality

PDX62

25-0029-ST-01

1. Device/process ID	2. PM ₁₀ PSEL (tons/year)	3. PM _{2.5} fraction (f)	4. Reference	5. PM _{2.5} PSEL (tons/yr)
SOFC	2.3	0.68	See emission calculations	1.6
TOTAL	2.3			1.6



HAZARDOUS AIR POLLUTANT (HAP) EMISSIONS DETAIL SHEET

FORM AQ403
ANSWER SHEET

Facility Name: PDX62

Permit Number: 25-0029-ST-01

Emissions Data

[illegible]

Applications for Standard ACDPs must also include the most recent Toxics Release Inventory report, if applicable (see instructions).



State of Oregon Department of Environmental Quality

Land Use Compatibility Statement

RECEIVED
MAY 18 2022

BY:

PAID
P+P

What is a Land Use Compatibility Statement?

A LUCS is a form developed by DEQ to determine whether a DEQ permit or approval will be consistent with local government comprehensive plans and land use regulations.

Why is a LUCS required?

DEQ and other state agencies with permitting or approval activities that affect land use are required by Oregon law to be consistent with local comprehensive plans and have a process for determining consistency. DEQ activities affecting land use and the requirement for a LUCS may be found in Oregon Administrative Rules (OAR) Chapter 340, Division 18.

When is a LUCS required?

A LUCS is required for nearly all DEQ permits and certain approvals of plans or related activities that affect land use prior to issuance of a DEQ permit or approval. These permits and activities are listed in section 1.D on p. 2 of this form. A single LUCS can be used if more than one DEQ permit or approval is being applied for concurrently.

Permit modifications or renewals also require a LUCS when any of the following applies:

1. Physical expansion on the property or proposed use of additional land;
2. Alterations, expansions, improvements or changes in method or type of disposal at a solid waste disposal site as described in OAR 340-093-0070(4)(b);
3. A significant increase in discharges to water;
4. A relocation of an outfall outside of the source property; or
5. Any physical change or change of operation of an air pollutant source that results in a net significant emission rate increase as defined in OAR 340-200-0020.

How to complete a LUCS:

Step	Who does it?	What happens?
1.	Applicant	Applicant completes Section 1 of the LUCS and submits it to the appropriate city or county planning office.
2.	City or County Planning Office	City or county planning office completes Section 2 of the LUCS to indicate whether the activity or use is compatible with the acknowledged comprehensive plan and land use regulations, attaches written findings supporting the decision of compatibility, and returns the signed and dated LUCS to the applicant.
3.	Applicant	Applicant submits the completed LUCS and any supporting information provided by the city or county to DEQ along with the DEQ permit application or approval request.

Where to get help:

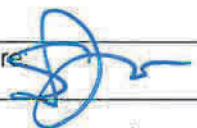
For questions about the LUCS process, contact the DEQ staff responsible for processing the permit or approval. DEQ staff may be reached at 1-800-452-4011 (toll-free, inside Oregon) or 503-229-5630. For general questions, please contact DEQ land use staff listed on our [Land Use Compatibility Statement page](#) online.

Cultural resources protection laws:

Applicants involved in ground-disturbing activities should be aware of federal and state cultural resources protection laws. ORS 358.920 prohibits the excavation, injury, destruction, or alteration of an archeological site or object or removal of archeological objects from public and private lands without an archeological permit issued by the State Historic Preservation Office. 16 USC 470, Section 106, National Historic Preservation Act of 1966 requires a federal agency, prior to any undertaking, to take into account the effect of the undertaking that is included on or eligible for inclusion in the National Register. For further information, contact the State Historic Preservation Office at 503-378-4168, ext. 232.

Land Use Compatibility Statement

Section 1 – To be completed by the applicant			
1A. Applicant Name: Amazon Web Services	1B. Project Name: PDX62		
Contact Name: Jason Bowker	Physical Address: 75300 Lewis and Clark Dr.		
Mailing Address: PO Box 80711	City, State, Zip: Boardman, OR 97818		
City, State, Zip: Seattle, WA 98108	Tax Lot #: 103		
Telephone: (541) 303-2380	Township: 4N Range: 26E Section: 07		
Tax Account #:	Latitude: 45°50'48.88"		
	Longitude: 119°36'23.43"		
1C. Describe the project, include the type of development, business, or facility and services or products provided (attach additional information if necessary): AWS operates data center PDX62 The facility houses computer systems, and associated components such as telecommunications and data storage systems. The principal use of the facility is the storage, management and dissemination of electronic data. AWS plans to install Solid Oxide Fuel Cell (SFCO) power at the facility, with an estimated capacity of 24.9 MW. The facility is currently authorized to operate diesel-fueled emergency generators.			
1D. Check the type of DEQ permit(s) or approval(s) being applied for at this time. <table style="width: 100%;"> <tr> <td style="width: 50%; vertical-align: top;"> ☐ Air Quality Notice of Construction ☒ Air Contaminant Discharge Permit ☐ Air Quality Title V Permit ☐ Air Quality Indirect Source Permit ☐ Parking/Traffic Circulation Plan ☐ Solid Waste Land Disposal Site Permit ☐ Solid Waste Treatment Facility Permit ☐ Solid Waste Composting Facility Permit (includes Anaerobic Digester) ☐ Conversion Technology Facility Permit ☐ Solid Waste Letter Authorization Permit ☐ Solid Waste Material Recovery Facility Permit ☐ Solid Waste Energy Recovery Facility Permit ☐ Solid Waste Transfer Station Permit ☐ Waste Tire Storage Site Permit ☐ Pollution Control Bond Request ☐ Hazardous Waste Treatment, Storage or Disposal Permit </td> <td style="width: 50%; vertical-align: top;"> ☐ Clean Water State Revolving Fund Loan Request ☐ Wastewater/Sewer Construction Plan/ Specifications (includes review of plan changes that require use of new land) ☐ Water Quality NPDES Individual Permit ☐ Water Quality WPCF Individual Permit (for onsite construction-installation permits use the DEQ Onsite LUCS form) ☐ Water Quality NPDES Stormwater General Permit (1200-A, 1200-C, 1200-CA, 1200-COLS, and 1200-Z) ☐ Water Quality General Permit (all general permits, except 600, 700-PM, 1700-A, and 1700-B when they are mobile) ☐ Water Quality 401 Certification for federal permit or license </td> </tr> </table>		☐ Air Quality Notice of Construction ☒ Air Contaminant Discharge Permit ☐ Air Quality Title V Permit ☐ Air Quality Indirect Source Permit ☐ Parking/Traffic Circulation Plan ☐ Solid Waste Land Disposal Site Permit ☐ Solid Waste Treatment Facility Permit ☐ Solid Waste Composting Facility Permit (includes Anaerobic Digester) ☐ Conversion Technology Facility Permit ☐ Solid Waste Letter Authorization Permit ☐ Solid Waste Material Recovery Facility Permit ☐ Solid Waste Energy Recovery Facility Permit ☐ Solid Waste Transfer Station Permit ☐ Waste Tire Storage Site Permit ☐ Pollution Control Bond Request ☐ Hazardous Waste Treatment, Storage or Disposal Permit	☐ Clean Water State Revolving Fund Loan Request ☐ Wastewater/Sewer Construction Plan/ Specifications (includes review of plan changes that require use of new land) ☐ Water Quality NPDES Individual Permit ☐ Water Quality WPCF Individual Permit (for onsite construction-installation permits use the DEQ Onsite LUCS form) ☐ Water Quality NPDES Stormwater General Permit (1200-A, 1200-C, 1200-CA, 1200-COLS, and 1200-Z) ☐ Water Quality General Permit (all general permits, except 600, 700-PM, 1700-A, and 1700-B when they are mobile) ☐ Water Quality 401 Certification for federal permit or license
☐ Air Quality Notice of Construction ☒ Air Contaminant Discharge Permit ☐ Air Quality Title V Permit ☐ Air Quality Indirect Source Permit ☐ Parking/Traffic Circulation Plan ☐ Solid Waste Land Disposal Site Permit ☐ Solid Waste Treatment Facility Permit ☐ Solid Waste Composting Facility Permit (includes Anaerobic Digester) ☐ Conversion Technology Facility Permit ☐ Solid Waste Letter Authorization Permit ☐ Solid Waste Material Recovery Facility Permit ☐ Solid Waste Energy Recovery Facility Permit ☐ Solid Waste Transfer Station Permit ☐ Waste Tire Storage Site Permit ☐ Pollution Control Bond Request ☐ Hazardous Waste Treatment, Storage or Disposal Permit	☐ Clean Water State Revolving Fund Loan Request ☐ Wastewater/Sewer Construction Plan/ Specifications (includes review of plan changes that require use of new land) ☐ Water Quality NPDES Individual Permit ☐ Water Quality WPCF Individual Permit (for onsite construction-installation permits use the DEQ Onsite LUCS form) ☐ Water Quality NPDES Stormwater General Permit (1200-A, 1200-C, 1200-CA, 1200-COLS, and 1200-Z) ☐ Water Quality General Permit (all general permits, except 600, 700-PM, 1700-A, and 1700-B when they are mobile) ☐ Water Quality 401 Certification for federal permit or license		
This application is for: ☐ Permit Renewal ☐ New Permit ☒ Permit Modification ☐ Other:			

Section 2 – To be completed by city or county planning official		
Applicant name: Amazon Web Services	Project name: PDX62	
Instructions: Written findings of fact for all local decisions are required; written findings from previous actions are acceptable. For uses allowed outright by the acknowledged comprehensive plan, DEQ will accept written findings in the form of a reference to the specific plan policies, criteria, or standards that were relied upon in rendering the decision with an indication of why the decision is justified based on the plan policies, criteria, or standards.		
2A. The project proposal is located: ☐ Inside city limits ☐ Inside UGB ☒ Outside UGB		
2B. Name of the city or county that has land use jurisdiction (the legal entity responsible for land use decisions for the subject property or land use): MORROW COUNTY PLANNING DEPARTMENT		
2C. ☒ This project is not within the jurisdiction of any other land use, zoning, or planning entity ☐ This project is also within the jurisdiction of the following land use, zoning, or planning entity:		
2D. Is the activity allowed under Measure 49 (2007)? ☐ No, Measure 49 is not applicable ☐ Yes, if yes, then check one:		
☐ Express; approved by DLCD order #:		
☐ Conditional; approved by DLCD order #:		
☐ Vested; approved by local government decision or court judgment docket or order #:		
2E. Is the activity a composting facility? ☒ No ☐ Yes; Senate Bill 462 (2013) notification requirements have been met.		
2F. Is the activity or use compatible with your acknowledged comprehensive plan as required by OAR 660-031? Please complete this form to address the activity or use for which the applicant is seeking approval (see 1.C on the previous page). If the activity or use is to occur in multiple phases, please ensure that your approval addresses the phases described in 1C. For example, if the applicant's project is described in 1C. as a subdivision and the LUCS indicates that only clearing and grading are allowed outright but does not indicate whether the subdivision is approved, DEQ will delay permit issuance until approval for the subdivision is obtained from the local planning official.		
☐ The activity or use is specifically exempt by the acknowledged comprehensive plan; explain:		
☐ Yes, the activity or use is pre-existing nonconforming use allowed outright by (provide reference for local ordinance):		
☒ Yes, the activity or use is allowed outright by (provide reference for local ordinance): MORROW COUNTY ZONING ORD. SECTION 3.073 PORT INDUSTRIAL		
☐ Yes, the activity or use received preliminary approval that includes requirements to fully comply with local requirements; findings are attached.		
☐ Yes, the activity or use is allowed; findings are attached.		
☐ No, see 2D. above, activity or use allowed under Measure 49; findings are attached.		
☐ No, (complete below or attach findings for noncompliance and identify requirements the applicant must comply with before compatibility can be determined): Relevant specific plan policies, criteria, or standards:		
Provide the reasons for the decision:		
Additional comments (attach additional information as needed):		
Planning Official Signature: 		Title: GIS PLANNING TECH
Print Name: WEESIAS, STEPHEN	Telephone #: 541.922.4624	Date: 25 MAY 2022
If necessary, depending upon city/county agreement on jurisdiction outside city limits but within UGB:		
Planning Official Signature:		Title:
Print Name:	Telephone #:	Date:

Alternative formats

DEQ can provide documents in an alternate format or in a language other than English upon request. Call DEQ at 800-452-4011 or email deqinfo@deq.state.or.us.

APPENDIX B. AIR EMISSIONS CALCULATIONS

- ▶ Air emissions calculations for the proposed SOFC are included in this appendix.

Table 1. SOFC Criteria, GHG, and HAP Pollutant Emission Rates

Daily Operating Hours:		24 hrs/day	
Annual Operating Hours:		8,760 hrs/yr	
Aggregate Fuel Cell Capacity:		24.3 MW	
NG Fuel Sulfur Content:		0.5 gr S/100 scf	
Pollutant	Emission Factor (lb/MWh) ^{1,2}	Hourly Emission Rate (lb/hr) ³	Annual Emission Rate (ton/yr) ⁴
PM ⁵	0.022	0.53	2.34
PM ₁₀ ⁵	0.022	0.53	2.34
PM _{2.5} ⁵	0.015	0.36	1.60
SO ₂	5.95E-06	1.45E-04	6.33E-04
NO _x	0.0017	0.041	0.18
CO	0.012	0.29	1.28
VOC	0.010	0.24	1.06
CO ₂ e	833	20,242	88,660
Benzene (71-43-2)	1.36E-05	3.30E-04	1.45E-03
Carbon disulfide (75-15-0)	4.80E-05	1.17E-03	5.11E-03
Methanol (67-56-1)	2.27E-04	5.52E-03	2.42E-02
Toluene (108-88-3)	4.43E-05	1.08E-03	4.72E-03
m, p, o-Xylene (1330-20-7)	3.06E-05	7.44E-04	3.26E-03
Total HAP	3.64E-04	0.0088	0.039

Table 2. Facility Total and Project Emissions Summary and PSEL Comparison

Pollutant	Potential Emissions			Plant Site Emission Limits (PSEL)			Synthetic Minor
	Current Facility Wide Non-Emergency ⁶	Current Facility Wide Non-Emergency and Emergency ⁶	Project Emissions	Current PSEL ⁷	PSEL Increase	Proposed PSEL ⁸	Post Project Facility Wide Non-Emergency and Emergency PTE ⁹
	(tpy)	(tpy)	(tpy)	(tpy)	(tpy)	(tpy)	(tpy)
PM	1.12	2.85	2.34	24	-	24	5.19
PM ₁₀	1.12	2.85	2.34	14	-	14	5.19
PM _{2.5}	1.12	2.85	1.60	9	-	9	4.44
SO ₂	0.030	0.083	6.33E-04	39	-	N/A	0.084
NO _x	39.00	98.93	0.18	39	-	39	99.11
CO	13.27	33.63	1.28	99	-	99	34.91
VOC	3.76	9.54	1.06	39	-	39	10.60
GHG (CO ₂ e)	3,395	8,597	88,660	74,000	18,054	92,054	97,257
Total HAP	0.095	0.24	0.039	N/A	N/A	N/A	0.28

¹ Emission factors for NO_x, CO, VOC, and CO₂e:
- Bloom Energy, Inc.; The Bloom Energy Server 5 Data Sheet; bloomenergy.com; 2022.
Emission factor for PM:
- Montrose Air Quality Services, LLC; Source Test Report, 2022 Engineering Testing, Bloom Energy, ES-5 "YUMA" Fuel Power Cell and Ambient Air Background, Sunnyvale, California; Document Number: W005AS-12216A-RT-1974; Test Date: January 11, 2022.
Emission factors for HAPs:
-Montrose 2021 Emissions Tests – ES-05 Fuel Cell fired on Natural Gas; Document Number W005AS-006509-RT-1458; dated 3/25/2021.

² Emissions of SO₂ are based on a fuel sulfur content of 0.5 gr S/100 scf for pipeline quality natural gas.
SO₂ Emission Factor (lb/MW hr) = Fuel Consumption (scf/hr)/ Rated Power (MW) / (359 scf NG/lb mol NG) x (0.005 lbmol SO₂/10⁶ lbmol NG) x (64 lb/lbmol SO₂)
Where Fuel Consumption = Rated Power (24.3 MW) * Heat Rate (6,562 BTU LHV/kW-hr) / NG LHV (983 BTU/SCF)

³ Hourly Emissions (lb/hr) = Emission Factor (lb/MWh) * Total Fuel Cell Capacity (MW/facility)

⁴ Annual Emissions (ton/yr) = Emission Factor (lb/MWh) * Fuel Cell Capacity (MW/facility) * Annual Operating Hours (hr/yr)

⁵ PM includes filterable and condensable particulate matter and assumes Total PM = PM₁₀. PM_{2.5} includes only condensable PM.

⁶ Current PTE as described in September 2021 Notice of Construction Application for security generator to Oregon DEQ. Non-emergency PTE is calculated using a limit of 39.0 tpy NO_x and weighting fuel throughput to each unit based on a ratio of kW availability, with fire pump fuel use considered constant. Non-emergency and emergency PTE is calculated using the permitted fuel limit of 760,838 gallons/yr using the same fuel weighting method.

⁷ Current PSEL from ACDP No. 25-0029-ST-01 Permit and Review Report issued April 20, 2018.

⁸ SO₂ does not require a PSEL since facility wide emissions remain less than de minimis levels. [OAR 340-222-0020(3)(a)]

⁹ This calculation is included to verify the facility remains a synthetic minor as it relates to the Title V Program.

APPENDIX C. SUPPORTING INFORMATION

This section includes the following supporting documentation:

- ▶ PM, PM₁₀, PM_{2.5}
 - Montrose Air Quality Services, LLC; Source Test Report, 2022 Engineering Testing, Bloom Energy, ES-5 “YUMA” Fuel Power Cell and Ambient Air Background, Sunnyvale, California; Document Number: W005AS-12216A-RT-1974; Test Date: January 11, 2022.
- ▶ SO₂
 - Pipeline-quality natural gas fuel sulfur content
- ▶ NO_x, CO, VOCs, and CO₂
 - Bloom Energy, Inc.; *The Bloom Energy Server 5 - Data Sheet*; bloomenergy.com; 2022.
- ▶ Hazardous Air Pollutants
 - Montrose Air Quality Services, LLC; *2021 Emissions Tests, Bloom Energy, ES5 fired on Natural Gas*; Document Number: W005AS-006509-RT-1458; Test Date: March 25, 2021.

SOURCE TEST REPORT 2022 ENGINEERING TESTING BLOOM ENERGY ES-5 "YUMA" FUEL POWER CELL AND AMBIENT AIR BACKGROUND SUNNYVALE, CALIFORNIA

Prepared For:

Bloom Energy
1299 Orleans Drive
Sunnyvale, CA 94089

Prepared By:

Montrose Air Quality Services, LLC
2825 Verne Roberts Circle
Antioch, CA 94509

Document Number:	W005AS-12216A-RT-1974
Test Date:	January 11, 2022
Submittal Date:	March 21, 2022



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REVIEW AND CERTIFICATION

All work, calculations, and other activities and tasks performed and presented in this document were carried out by me or under my direction and supervision. I hereby certify that, to the best of my knowledge, Montrose operated in conformance with the requirements of the Montrose Quality Management System and ASTM D7036-04 during this test project.

Signature: _____ Date: _____

Name: Finn Schall Title: Client Project Manager

I have reviewed, technically and editorially, details, calculations, results, conclusions, and other appropriate written materials contained herein. I hereby certify that, to the best of my knowledge, the presented material is authentic, accurate, and conforms to the requirements of the Montrose Quality Management System and ASTM D7036-04.

Signature: _____ Date: _____

Name: Dan Duncan Title: Reporting Hub Manager

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1.0 INTRODUCTION

1.1 SUMMARY OF TEST PROGRAM

Bloom Energy (Bloom) contracted Montrose Air Quality Services, LLC (Montrose) to perform a test program on the sources listed in Table 1-1 at the facility located in Sunnyvale, California. The tests were conducted to provide emissions data for in-house engineering purposes.

The specific objectives were to:

- Determine emissions of PM₁₀ and PM_{2.5}
- Conduct the test program with a focus on safety

Montrose performed the tests to measure the emission parameters listed in Table 1-1.

**TABLE 1-1
SUMMARY OF TEST PROGRAM**

Test Date	Unit ID/ Source Name	Activity/ Parameters	Test Methods	No. of Runs	Duration (Minutes)
1/11/22	ES-5 fuel cell energy server "Yuma"	Velocity/Volumetric Flow Rate	EPA 1 & 2	3	60
1/11/22	ES-5 fuel cell energy server "Yuma"	Moisture	EPA 4	3	60
1/11/22	ES-5 fuel cell energy server "Yuma"	TPM	EPA 5/202	3	60
1/11/22	Background	TPM	EPA 5/202	3	60

To simplify this report, a list of Units and Abbreviations is included in Appendix D.1. Throughout this report, chemical nomenclature, acronyms, and reporting units are not defined. Please refer to the list for specific details.

This report presents the test results and supporting data, descriptions of the testing procedures, descriptions of the facility and sampling locations, and a summary of the quality assurance procedures used by Montrose. The average emission test results are summarized and compared to their respective permit limits in Table 1-2. Detailed results for individual test runs can be found in Section 4.0. All supporting data can be found in the appendices.

The testing was conducted by the Montrose personnel listed in Table 1-3. The tests were conducted according to the proposal dated October 22, 2021 that was submitted to and approved by Bloom.

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TABLE 1-2
SUMMARY OF AVERAGE ENGINEERING RESULTS -
ES-5 FUEL CELL ENERGY SERVER "YUMA"
BLOOM ENERGY
JANUARY 11, 2022

Parameter/Units	ES-5 "Yuma"	Ambient Air Background	ES-5 "Yuma" (Corrected) ¹
Unit Data:			
Energy Produced (D/C), Kw	55.6	--	
Filterable Particulate Matter (PM)			
gr/dscf	0.000292	--	--
lb/hr	0.00035	--	--
lb/MW-hr	0.0063	--	--
Condensable Particulate Matter (PM)			
gr/dscf	0.000710	--	--
lb/hr	0.00086	--	--
lb/MW-hr	0.015	--	--
Total Particulate Matter (PM)			
gr/dscf	0.001002	0.000016	0.000986
lb/hr	0.00121	--	0.00119
lb/MW-hr	0.022	--	0.021

¹ The results presented in this table are representative of the emissions from ES-5 corrected for the concentrations in the background ambient air. See Section 4.2 for details. All test results are calculated based on a reference temperature of 60°F. Diluent concentrations were assumed to be ambient.

Due to the small duct size, particle sizing equipment could not be utilized effectively. Sampling therefore included total Filterable PM and condensable PM. See Section 4.2 for an explanation of how results relate to PM₁₀ and PM_{2.5}.

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1.2 KEY PERSONNEL

A list of project participants is included below:

Facility Information

Source Location:	Bloom Energy Moffett Field Electrolyzer Mountain View, CA	
Project Contact:	Sri Raghavan	Andy Ta
Telephone:	(408) 543-1500	--
Email:	Sri.Raghavan@bloomenergy.com	Andy.Ta@bloomenergy.com

Testing Company Information

Testing Firm:	Montrose Air Quality Services, LLC (Montrose)	
Contact:	Finnegan Schall	Max Jakovleski
Title:	Client Project Manager	District Manager
Telephone:	913-530-4713	925-750-0326
Email:	fschall@montrose-env.com	mpjakovleski@montrose-env.com

Laboratory Information

Laboratory:	Montrose
City, State:	Antioch, CA
Methods:	EPA 5/202
Laboratory:	Desert Research Institute (DRI)
City, State:	Antioch, CA
Methods:	EPA 5/202

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Test personnel and observers are summarized in Table 1-3.

**TABLE 1-3
TEST PERSONNEL AND OBSERVERS**

Name	Affiliation	Role/Responsibility
Finn Schall	Montrose	Project Manager/Field Team Leader/Qualified Individual (QI)/Trailer operator/Sample recovery/Sample train operator
Ryan Vogler	Montrose	Sample recovery/Sample train operator
Kevin Siegmann	Montrose	Sample train operator
Patrick Switzer	Montrose	Calculations and report preparation
Rudy Ruvalcaba	Bloom	Observer/Client Liaison/Test Coordinator

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2.0 PLANT AND SAMPLING LOCATION DESCRIPTIONS

2.1 PROCESS DESCRIPTION, OPERATION, AND CONTROL EQUIPMENT

The facility is used to test Bloom Energy's fuel cell systems called Energy Servers. The focus of the test program was Bloom's Energy Server 5 (ES5) 300 kW fuel cell system as well as the facility's background (ambient) emissions. The ES-5 is fueled by natural gas and is comprised of 6 Power Modules which are each capable of outputting 50kW AC totaling 300kW AC for the entire Energy Server. The unit may be fueled on hydrogen, natural gas, or directed biogas. Exhaust gas from the cathode ordinarily vents to the atmosphere through a rectangular grating. For this test, the exhaust gas was redirected through a piece of transition ducting to a temporarily-installed cylindrical stack extension.

2.2 SAMPLING LOCATIONS

Information regarding the sampling locations is presented in Table 2-1.

**TABLE 2-1
SAMPLING LOCATIONS**

Sampling Location	Stack Inside Diameter (in.)	Distance from Nearest Disturbance		Number of Traverse Points
		Downstream EPA "B" (in.)	Upstream EPA "A" (in.)	
ES-5	6	89	30	Flow: 12 (6/port); Gaseous: 3
Background ¹	N/A	N/A	N/A	Single point

See Appendix A.1 for more information.

2.3 OPERATING CONDITIONS AND PROCESS DATA

Emission tests were performed while the source/units and air pollution control devices were operating at the conditions required by the permit. The tests were conducted under the following conditions:

- ES-5 Natural Gas Powered – 50kW AC output power, Natural Gas

Plant personnel were responsible for establishing the test conditions and collecting all applicable unit-operating data. The process data that was provided is presented in Appendix B. Data collected includes the following parameters:

- Fuel flow rates
- Air flow rates
- Rated DC/AC Power output

¹ Ambient air samples were collected as background by drawing air through a cassette filter. See Section 3.1.5 for details.

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3.0 SAMPLING AND ANALYTICAL PROCEDURES

3.1 TEST METHODS

The test methods for this test program were presented previously in Table 1-1. Additional information regarding specific applications or modifications to standard procedures is presented below.

3.1.1 EPA Method 1, Sample and Velocity Traverses for Stationary Sources

EPA Method 1 is used to assure that representative samples or measurements of volumetric flow rate are obtained by dividing the cross-section of the stack or duct into equal areas, and then locating a traverse point within each of the equal areas. Acceptable sample locations must be located at least two stack or duct equivalent diameters downstream from a flow disturbance and one-half equivalent diameter upstream from a flow disturbance.

The sample port and traverse point locations are detailed in Appendix A.

3.1.2 EPA Method 2, Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)

EPA Method 2 is used to measure the gas velocity using an S-type pitot tube connected to a pressure measurement device, and to measure the gas temperature using a calibrated thermocouple connected to a thermocouple indicator. Typically, Type S (Stausscheibe) pitot tubes conforming to the geometric specifications in the test method are used, along with an inclined manometer. The measurements are made at traverse points specified by EPA Method 1. The molecular weight of the gas stream is determined from independent measurements of O₂, CO₂, and moisture. The stack gas volumetric flow rate is calculated using the measured average velocity head, the area of the duct at the measurement plane, the measured average temperature, the measured duct static pressure, the molecular weight of the gas stream, and the measured moisture.

3.1.3 EPA Method 4, Determination of Moisture Content in Stack Gas

EPA Method 4 is a manual, non-isokinetic method used to measure the moisture content of gas streams. Gas is sampled at a constant sampling rate through a probe and impinger train. Moisture is removed using a series of pre-weighed impingers containing methodology-specific liquids and silica gel immersed in an ice water bath. The impingers are weighed after each run to determine the percent moisture.

Pertinent information regarding the performance of the method is presented below:

- Method Options:
 - Condensed water is measured gravimetrically
- Method Exceptions:
 - Moisture sampling is combined with EPA Method 5 sampling
- Target and/or Minimum Required Sample Duration: 60 minutes

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3.1.4 EPA Methods 5 and 202, Determination of Particulate Matter from Stationary Sources and Dry Impinger Method for Determining Condensable Particulate Emissions from Stationary Sources

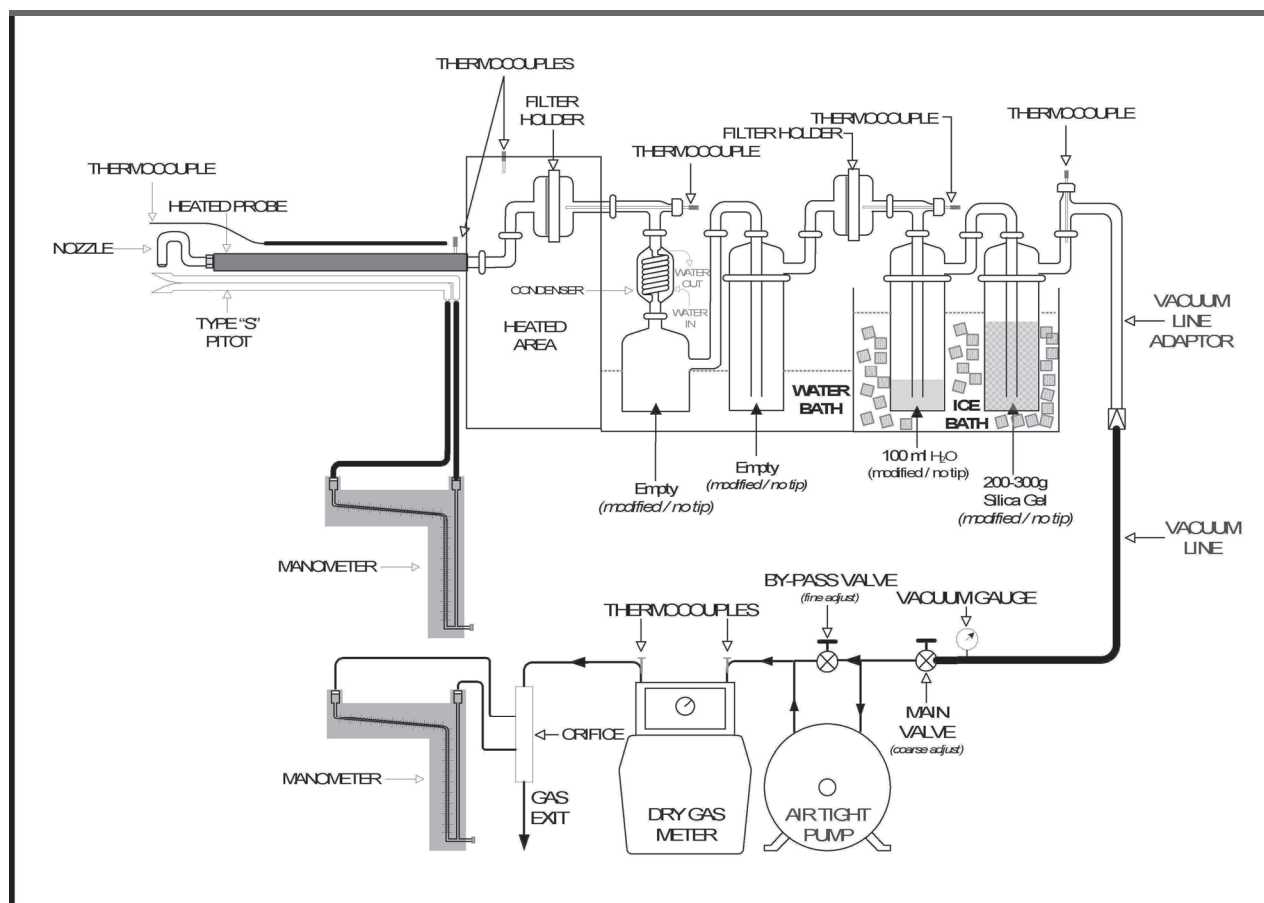
EPA Methods 5 and 202 are manual, isokinetic methods used to measure FPM and CPM emissions. The methods are performed in conjunction with EPA Methods 1 through 4. The stack gas is sampled through a nozzle, probe, heated filter, unheated CPM filter, condenser, and impinger train. FPM is collected from the probe and heater filter. CPM is collected from the unheated CPM filter and the impinger train. The samples are analyzed gravimetrically. The sum of FPM and CPM represents TPM. The FPM, CPM, and TPM results are reported in emission concentration and emission rate units. Pertinent information regarding the performance of the method is presented below:

- Method Options:
 - Glass sample nozzles and probe liners are used
 - Condensed water is measured gravimetrically
 - Polyethylene wash bottles and sample bottles are used
 - As an alternative to baking glassware, a field train proof blank sample is recovered
 - No water is collected before the CPM filter; therefore, the post-test nitrogen purge is omitted
 - Selected due to size of ducting to reduce area of flow obstruction during sampling
- Method Exceptions:
 - None
- Target and/or Minimum Required Sample Duration: 60 minutes
- Target and/or Minimum Required Sample Volume: 30 dscf
- Analytical Laboratory: Montrose, Antioch, CA

The typical sampling system is detailed in Figure 3-1.

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**FIGURE 3-1
EPA METHOD 5/202 SAMPLING TRAIN**



3.1.5 EPA Method 5 (modified), Determination of Particulate Matter Concentration in Ambient Air

EPA Method 5 is modified for measurement of the total particulate matter concentrations in the ambient air drawn into the Bloom system. A standard Method 5 sampling control box and pump is used to draw a measured volume of air through a filter. The filter is at ambient temperature; as long as the filter temperature is no more than 85 degrees F, the sample includes condensable particulate matter. The filter is a Teflon membrane filter in a cassette filter holder of the same type used in ambient air monitoring stations.

- Method Exceptions:
 - No sampling probe; cassette filter holder used in place of the standard Method 5 nozzle, probe, filter holder and impinger train.
 - Standard Method 5 glass fiber filter replaced with a 47 mm Teflon membrane filter mounted in an ambient monitoring cassette filter holder. Filter holder mounted approximately 2 feet above the floor and within 25 feet from the Unit's air intake.
 - Filter weighed according to standard EPA ambient monitoring procedure.

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- Target and/or Minimum Required Sample Duration: 60 minutes
- Target and/or Minimum Required Sample Volume: 40 dscf
- Analytical Laboratory: Desert Research Institute, Reno, NV

3.2 PROCESS TEST METHODS

The test plan did not require that process samples be collected during this test program; therefore, no process sample data are presented in this test report.

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4.0 TEST DISCUSSION AND RESULTS

4.1 FIELD TEST DEVIATIONS AND EXCEPTIONS

No field deviations or exceptions from the proposal or test methods occurred during this test program.

4.2 PRESENTATION OF RESULTS

The average results are presented in Table 1-2. The results of individual test runs are presented in Tables 4-1 and 4-2. Emissions are reported in units consistent with those in the applicable regulations or requirements. Additional information is included in the appendices as presented in the Table of Contents.

Note that the small exhaust duct size (6-inch diameter) precludes the use of EPA Method 201A apparatus for separation of the Filterable PM into aerodynamic size fractions. Filterable PM₁₀ is considered to be a subset of the Total Filterable PM, and Filterable PM_{2.5} is considered a subset of PM₁₀.

The Condensable PM is considered by EPA to be very small particles; that is, all PM_{2.5} and therefore part of PM₁₀ and the Total PM as well.

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TABLE 4-1
PARTICULATE MATTER EMISSIONS RESULTS -
ES-5 FUEL CELL ENERGY SERVER "YUMA"
BLOOM ENERGY

Run Number	1	2	3	Average
Date	1/11/22	1/11/22	1/11/22	--
Time	1907-2009	2038-2140	2207-2309	--
Process Data				
Energy production (D/C), KW	55.6	55.6	55.6	55.6
Sampling & Flue Gas Parameters				
sample duration, minutes	60	60	60	--
O ₂ , % volume dry	20.9	20.9	20.9	20.9
CO ₂ , % volume dry	<0.1	<0.1	<0.1	<0.1
flue gas temperature, °F	551	548	545	548
moisture content, % volume	8.4	8.7	9.0	8.7
volumetric flow rate, dscfm	143	140	140	141
Filterable Particulate Matter				
gr/dscf	0.000215	0.000312	0.000349	0.000292
lb/hr	0.00026	0.00038	0.00042	0.00035
lb/MW-hr	0.0047	0.0068	0.0075	0.0063
Condensable Particulate Matter				
gr/dscf	0.000543	0.001040	0.000548	0.000710
lb/hr	0.00066	0.00125	0.00066	0.00086
lb/MW-hr	0.012	0.022	0.012	0.015
Total Particulate Matter				
gr/dscf	0.000757	0.001353	0.000897	0.001002
lb/hr	0.00093	0.00162	0.00108	0.00121
lb/MW-hr	0.017	0.029	0.019	0.022

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TABLE 4-2
PARTICULATE MATTER EMISSIONS RESULTS -
BLOOM ENERGY AMBIENT AIR BACKGROUND CONCENTRATIONS

Run Number	1	2	3	Average
Date	1/11/22	1/11/22	1/11/22	--
Time	1907-2007	2038-2138	2207-2307	--
Process Data				
Energy production (D/C), KW	55.6	55.6	55.6	55.6
Sampling & Flue Gas Parameters				
sample duration, minutes	60	60	60	--
O ₂ , % volume dry	20.9	20.9	20.9	20.9
CO ₂ , % volume dry	<0.1	<0.1	<0.1	<0.1
Filterable Particulate Matter				
gr/dscf	0.000014	0.000016	0.000017	0.000016

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5.0 INTERNAL QA/QC ACTIVITIES

5.1 QA/QC AUDITS

The meter boxes and sampling trains used during sampling performed within the requirements of their respective methods. All post-test leak checks, minimum metered volumes, minimum sample durations, and percent isokinetics met the applicable QA/QC criteria, except where noted in Section 5.2.

EPA Method 5 analytical QA/QC results are included in the laboratory report. The method QA/QC criteria were met, except if noted in Section 5.2. An EPA Method 5 reagent blank was analyzed. The maximum allowable amount that can be subtracted is 0.001% of the weight of the acetone blank. The blank did not exceed the maximum residue allowed, except where noted in Section 5.2.

EPA Method 202 analytical QA/QC results are included in the laboratory report. The method QA/QC criteria were met, except where noted in Section 5.2. An EPA Method 202 Field Train Recovery Blank (FTRB) was performed for each source category. The maximum allowable amount that can be subtracted is 0.002 g (2.0 mg). For this project, the FTRB had a mass of 0.91 mg, and 0.91 mg was subtracted.

5.2 QA/QC DISCUSSION

All QA/QC criteria were met during this test program.

5.3 QUALITY STATEMENT

Montrose is qualified to conduct this test program and has established a quality management system that led to accreditation with ASTM Standard D7036-04 (Standard Practice for Competence of Air Emission Testing Bodies). Montrose participates in annual functional assessments for conformance with D7036-04 which are conducted by the American Association for Laboratory Accreditation (A2LA). All testing performed by Montrose is supervised on site by at least one Qualified Individual (QI) as defined in D7036-04 Section 8.3.2. Data quality objectives for estimating measurement uncertainty within the documented limits in the test methods are met by using approved test protocols for each project as defined in D7036-04 Sections 7.2.1 and 12.10. Additional quality assurance information is included in the report appendices. The content of this report is modeled after the EPA Emission Measurement Center Guideline Document (GD-043).

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APPENDIX A FIELD DATA AND CALCULATIONS

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Appendix A.1

Sampling Locations



EPA METHOD 1 FIELD DATA

Project Information

Client / Facility

Bloom Energy

Date

1/11/22

Source / Location

YUMA

Data taken by

KS/RV

Duct Measurements

Type of duct (circular, rectangular, elliptical)

Circular

Far wall to outside of port distance, in.: M1

N/A

Port length, in. (confirm flush with inside wall): M2

N/A

Duct inner diameter, in. (M1 - M2)

6

Duct ID using adjacent, 90° port (for elliptical ducts)

N/A

Upstream distance (A), in.

26

Downstream distance (B), in.

83

Number of ports (for circular, must be 90° to each other)

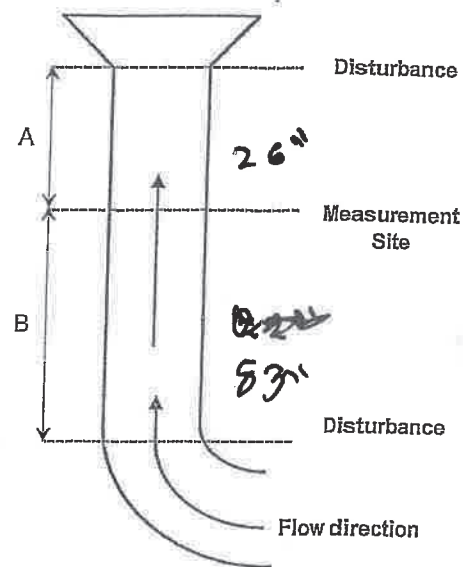
N/A

Internal width (for rectangular ducts only), in. *

N/A

Port inner diameter, in.

N/A



Duct Parameters

Material (steel, fiberglass, PVC)

Steel

Type of port (flange, npt nipple, etc.)

N/A

Orientation (vertical, horizontal, if diagonal specify angle)

hor: 20°/m

Elevation of ports above ground, ft.

52

Cyclonic flow expected?

NO

Pitot ID

82-TP-4

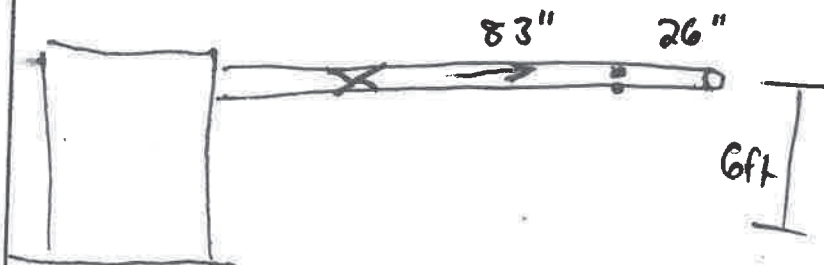
Manometer ID

CB-23

Angle finder / protractor ID

-

Diagram of duct and sampling location



Traverse point	Outside port distance, in.	Null angle, α
4	5.5	4.3
3	4.5	4.1
2	1.5	3.9
1	0.5	4.0
4	6.5	2.7
3	4.5	3.6
2	1.5	3.3
1	0.5	3.9

Cross-section sketch showing port locations and numbering

Label the following: port number 1, 2, etc.

north direction or other landmark

flow direction - $\otimes$ into page $\odot$ out of pageAverage of absolute α

*If schematics are unavailable, internal width can be estimated by measuring the portion of the port length not visible on the outside of the duct, which would be an estimate of the insulation thickness. Double this distance and subtract it from the outside width.

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Appendix A.2

Particulate Matter Data Sheets

Page 1 of 1[illegible]

Page 1 of 1[illegible]



5 Method 202 Field Datasheet (Isokinetic)

Page 1 of 1

Project Information				Sampling Conditions				ALT 011 TC ID: Ambient °F Ref. °F			
Date	1-11-22	Project #	012216	Static Pressure, in. H ₂ O	-1.05	Ambient Temp, °F	50	Stack	91 NP 3	46	46.1
Customer/Facility	Bloom Energy	Barometric Pressure, in. Hg	30.26	Ref. Barometer ID	10621	Probe	91 NP 3	46	46.1		
Unit ID/Sample Location	WTA8 YUMA 1-11-22	Wind Speed / Direction	none	Precipitation, Y/N/Type	0	Filter Box	OS 20	46	46.0		
Run #	3	Operator	KS YUMA	Probe / Filter Temp Range, °F	22-28	Filter Exit					
Sampling Equipment IDs				Equipment Checks				Meter outlet			
Meterbox ID	CB 10	Calibration	1.004	Pitot (+), pass @ in. H ₂ O	Pre	Mid	Post	Meter outlet	CB 10	46	45.9
Umbilical ID	UL 303	Meterbox ΔH@, in. H ₂ O	1.727	Pitot (-), pass @ in. H ₂ O	4	4	4	Impinger Exit	GN 8	46	45.9
Nozzle ID	194-380-A	Nozzle diameter, Dn, in.	0.380	Pitot visual inspection	pass	pass	pass	Other			
Pitot / Probe ID	91 NP 3	Pitot coefficient, Cp	0.84	Nozzle visual inspection	pass	pass	pass	Ref. Thermometer ID	Trailor 8		
Manometer ID	CB 10	Manometer zero and level	yes	Meter, cfm @ in. Hg	0.005 @ 10	0	0.002 @ 10	Continuity Check	Continuity w/ Proper Polarity		
Sensitivity	0.1	K-Factor	10.38	Intermediate leak check volume, ft ³				Notes:			
Traverse Point #	Elapsed Time	Clock Time 24hr	DGM Reading, Vm, ft ³	Velocity Head, ΔP in H ₂ O	Orifice Pressure Differential, ΔH	Stack Temp, °F	Probe Temp, °F	Filter Temp, °F	Impinger Exit Temp, °F	Dry Gas Meter Temperature, °F	Pump Vacuum, in. Hg
					Target Actual			Box Exit		Inlet Outlet	
1	0	22:07	867.256	.11	1.14 1.1	544	248	243	52	54 75	5
2	7.5	22:14:50	871.68	.12	1.24 1.2	546	249	247	51	54 75	5
3	15	22:22	876.10	.10	1.03 1.0	545	249	245	55	55 76	5
4	22.5	22:29:30	880.24	.08	0.80 0.8	545	249	245	56	56 75	5
PC	30	22:37	884.552								
5	30	22:38	884.552	.10	1.03 1.0	545	249	246	48	55 75	5
6	37.5	22:46:30	889.07	.13	1.34 1.3	546	249	247	45	56 76	5
7	45	22:54	893.51	.11	1.14 1.1	546	248	248	44	56 75	5
8	52.5	23:01:30	897.36	.07	0.726 0.73	544	248	247	42	56 76	5
END	60	23:09	901.250								
Averages	60		33.997	0.1016	1.033	545.1				55.3	

QA/QC Check: Completeness _____ Legibility _____ Accuracy _____ Specifications _____ Checked By _____ Team Leader _____

001AS-QMS-FM-225



Sample Recovery & Calibration Check Datasheet

Page 1 of 1

Project Information		Equipment Identification	
Date	<u>1/11/22</u>	Project #	<u>PROS-012216</u>
Customer / Facility	<u>Bloom Energy</u>	Ref. Thermometer	<u>—</u>
Unit ID / Sample Location	<u>Yuma</u>	Hygrometer	<u>—</u>
Run #	<u>1-3-PM</u>	Field Balance	<u>18-AB-0A1C-T8</u>
Operator	<u>Rv</u>	Check Weights	<u>W-10</u>
		Calipers	<u>ANT-CAL7</u>

Balance Audit (Field balance must be within 0.5g of check weight mass)		Ambient Conditions (Mobile Lab)	
Date	<u>1/11/21</u>	Relative humidity, %	<u>—</u>
Standard mass, g	<u>500g</u>	Temperature, °F	<u>60</u>
Field balance mass, g	<u>499.8g</u>	Mobile lab #	<u>T8</u>

Moisture Determination										
		Run1			Run 2			Run 3		
	Contents	Initial	Final	Net	Initial	Final	Net	Initial	Final	Net
Knockout	MT	622.4	703.3	80.9	628.4	712.5	84.1	663.0	737.1	77.5
Impinger 1	MT	660.8	660.9	0.1	659.6	659.0	-0.6	659.6	665.6	2.6
Impinger 2	100% H2O	647.0	645.3	-1.7	660.8	660.1	-0.7	692.5	693.9	1.4
Impinger 3	Silica	930.1	940.2	10.1	930.4	938.7	8.3	931.8	944.1	12.3
Impinger 4										
Impinger 5										
Impinger 6										
Impinger 7										
Impinger 8										
Silica Gel										
Line Rinse	LR Rinse H2O	20	0	-20	20	0	-20	20	0	-20
Train Net Gain (Vlc)				69.4			74.1			73.8

Nozzle Measurements (Difference between any two measurements must not be more than 0.004 in (0.1 mm))								
Nozzle 1 diameters	<u>0.380</u>	D1	<u>0.380</u>	D2	<u>0.380</u>	D3	<u>0.380</u>	Average
Nozzle 2 diameters	<u>—</u>	D1	<u>—</u>	D2	<u>—</u>	D3	<u>—</u>	Average
Nozzle 3 diameters	<u>—</u>	D1	<u>—</u>	D2	<u>—</u>	D3	<u>—</u>	Average
Nozzle Material	quartz	<u>glass</u>	steel	titanium	inconel	other		
Probe Type	<u>heated</u>	unheated	air-cooled	water-cooled	other			
Probe Liner	quartz	<u>glass</u>	steel	Teflon	other			

Filter Information						
Front Half:	quartz fiber	glass fiber	Teflon	Teflon/quartz	other	<u>Teflon Backed Glass</u>
Filter Number:	Run 1: <u>2326</u>	Run 2: <u>2331</u>	Run 3: <u>2285</u>	Run	:	
Back Half:	quartz fiber	glass fiber	<u>Teflon</u>	Teflon/quartz	other	

Reagent Information		Sample Observations
Type	Lot Number	
<u>Type II H₂O</u>	<u>R000540</u>	
<u>Acetone</u>	<u>R000589</u>	
<u>Hexane</u>	<u>R000588</u>	

QA/QC Check: Completeness ____ Legibility ____ Accuracy ____ Specifications ____

Checked by: _____ Team Leader: _____

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EPA Method S202 Field Datasheet (Isokinetic)Page 1 of 1

Project Information <u>1-11-22</u>				Sampling Conditions				ALT 011 TC ID: Ambient °F Ref. °F																															
Date <u>11-22-22</u>	Project # <u>PROJ-012216</u>			Static Pressure, in. H ₂ O <u>—</u>	Ambient Temp, °F <u>60</u>			Stack	Probe																														
Customer/Facility <u>Bloom Energy</u>				Barometric Pressure, in. Hg <u>30.02</u>	Ref. Barometer ID <u>—</u>			Filter Box	Filter Exit																														
Unit ID/Sample Location <u>YUMA Ambient</u>				Wind Speed / Direction <u>0 MPH</u>	Precipitation, Y/N/Type <u>—</u>			Meter outlet	Impinger Exit																														
Run # <u>1-PM-Ambient</u> Operator <u>RV/KS</u>				Probe / Filter Temp Range, °F <u>—</u>			Other	Ref. Thermometer ID			Continuity Check ☐ Continuity w/ Proper Polarity																												
Sampling Equipment IDs				Equipment Checks				Notes:																															
Meterbox ID <u>CB-23</u>	Calibration			<table border="1"> <thead> <tr> <th></th> <th>Pre</th> <th>Mid</th> <th>Post</th> </tr> </thead> <tbody> <tr> <td>Pitot (+), pass @ in. H₂O</td> <td>☐ @</td> <td>☐ @</td> <td>☐ @</td> </tr> <tr> <td>Pitot (-), pass @ in. H₂O</td> <td>☐ @</td> <td>☐ @</td> <td>☐ @</td> </tr> <tr> <td>Pitot visual inspection</td> <td>☐ pass</td> <td>☐ pass</td> <td>☐ pass</td> </tr> <tr> <td>Nozzle visual inspection</td> <td>☐ pass <u>RV</u></td> <td>☐ pass</td> <td>☐ pass</td> </tr> <tr> <td>Meter, cfm @ in. Hg</td> <td><u>0.005 @ 15</u></td> <td><u>@</u></td> <td><u>0.004 @ 16</u></td> </tr> <tr> <td>Intermediate leak check volume, ft³</td> <td><u>15</u></td> <td><u>1</u></td> <td><u>1</u></td> </tr> </tbody> </table>					Pre	Mid	Post	Pitot (+), pass @ in. H ₂ O	☐ @	☐ @	☐ @	Pitot (-), pass @ in. H ₂ O	☐ @	☐ @	☐ @	Pitot visual inspection	☐ pass	☐ pass	☐ pass	Nozzle visual inspection	☐ pass <u>RV</u>	☐ pass	☐ pass	Meter, cfm @ in. Hg	<u>0.005 @ 15</u>	<u>@</u>	<u>0.004 @ 16</u>	Intermediate leak check volume, ft ³	<u>15</u>	<u>1</u>	<u>1</u>	Meter outlet <u>PCUN</u>			
	Pre	Mid	Post																																				
Pitot (+), pass @ in. H ₂ O	☐ @	☐ @	☐ @																																				
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Pitot visual inspection	☐ pass	☐ pass	☐ pass																																				
Nozzle visual inspection	☐ pass <u>RV</u>	☐ pass	☐ pass																																				
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Intermediate leak check volume, ft ³	<u>15</u>	<u>1</u>	<u>1</u>																																				
Umbilical ID <u>UL-201</u>	Meterbox Y <u>0.985</u>			Pitot (+), pass @ in. H ₂ O				Impinger Exit																															
Nozzle ID <u>—</u>	Meterbox ΔH @ in. H ₂ O <u>1.853</u>			Pitot (-), pass @ in. H ₂ O				Other <u>3</u>																															
Pitot / Probe ID <u>—</u>	Nozzle diameter, Dn, in. <u>—</u>			Pitot visual inspection				Ref. Thermometer ID																															
Manometer ID <u>CB-23</u>	Pilot coefficient, Cp <u>0.84</u>			Nozzle visual inspection				Continuity Check ☐ Continuity w/ Proper Polarity																															
Sensitivity <u>0.01</u>	Manometer zero and level ☒ Yes			Meter, cfm @ in. Hg				Notes:																															
	K-Factor <u>ΔH = RV</u> <u>ΔH = 1.5</u>			Intermediate leak check volume, ft ³																																			

Traverse Point #	Elapsed Time	Clock Time 24hr	DGM Reading, Vm, ft ³	Velocity Head, ΔP in H ₂ O	Orifice Pressure Differential, ΔH		Stack Temp, °F	Probe Temp, °F	Filter Temp, °F		Impinger Exit Temp, °F	Dry Gas Meter Temperature, °F		Pump Vacuum, in. Hg
					Target	Actual			Box	Exit		Inlet	Outlet	
0	1907	319.24	1.5	1.5	—	—	—	—	54	—	61	—	5.0	
10	1917	325.89	—	—	—	—	—	—	51	—	61	—	14	
20	1927	332.78	—	—	—	—	—	—	55	—	62	—	14	
30	1937	339.87	—	—	—	—	—	—	59	—	62	—	14	
40	1947	346.56	—	—	—	—	—	—	61	—	64	—	15	
50	1957	352.99	—	—	—	—	—	—	63	—	65	—	14	
60	2007	359.912	—	—	—	—	—	—	—	—	—	—	—	
Averages														
<u>60</u> <u>40.672</u> <u>1.5</u> <u>1.5</u> <u>—</u> <u>—</u> <u>—</u> <u>—</u> <u>62.5</u>														

QA/QC Check: Completeness — Legibility — Accuracy — Specifications — Checked By — Team Leader —

001AS-QMS-FM-225


 EPA Method 5/200 Field Datasheet (Isokinetic)

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Project Information Date <u>1/11/21</u> Project # <u>PROJ-012216</u> Customer/Facility <u>Bloom Energy</u> Unit ID/Sample Location <u>YUMA Ambient</u> Run # <u>2-PM-AMB</u> Operator <u>RJ</u>				Sampling Conditions Static Pressure, in. H ₂ O <u>- 30.20</u> Ambient Temp, °F <u>60</u> Barometric Pressure, in. Hg <u>30.02</u> Ref. Barometer ID <u>W001</u> Wind Speed / Direction <u>0 MPH</u> Precipitation, Y/N <u>type</u> Probe / Filter Temp Range, °F <u>-</u>				ALT 011 TC ID: Ambient °F Ref. °F Stack Probe Filter Box Filter Exit Meter outlet Impinger Exit Other Ref. Thermometer ID Continuity Check ☐ Continuity w/ Proper Polarity Notes: <u>\$ RJ 1/11/21</u>																																																																																																																		
Sampling Equipment IDs Meterbox ID <u>CB23</u> Umbilical ID <u>UL-201</u> Nozzle ID <u>-</u> Pitot / Probe ID <u>-</u> Manometer ID <u>CB-23</u> Sensitivity <u>0.01</u>		Calibration Meterbox Y <u>0.985</u> Meterbox ΔH@, in. H ₂ O <u>1.853</u> Nozzle diameter, Dn, in. <u>-</u> Pitot coefficient, Cp <u>0.84</u> Manometer zero and level ☒ Yes K-Factor <u>ΔH = 1.5</u>		Equipment Checks Pitot (+), pass @ in. H ₂ O ☒ @ Pitot (-), pass @ in. H ₂ O ☒ @ Pitot Visual Inspection ☒ pass Nozzle visual inspection ☒ pass Meter, cfm @ in. Hg <u>0.003 @ 17</u> Intermediate leak check volume, ft ³ <u>@ 0.005 @ 17</u>		<table border="1"> <thead> <tr> <th>Pre</th> <th>Mid</th> <th>Post</th> </tr> </thead> <tbody> <tr> <td>☒ @</td> <td>☒ @</td> <td>☒ @</td> </tr> <tr> <td>☒ pass</td> <td>☒ pass</td> <td>☒ pass</td> </tr> <tr> <td>☒ pass</td> <td>☒ pass</td> <td>☒ pass</td> </tr> </tbody> </table>		Pre	Mid	Post	☒ @	☒ @	☒ @	☒ pass	☒ pass	☒ pass	☒ pass	☒ pass	☒ pass																																																																																																							
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Traverse Point #	Elapsed Time	Clock Time 24hr	DGM Reading, Vm, ft ³	Velocity Head, ΔP in H ₂ O	Orifice Pressure Differential, ΔH	Stack Temp, °F	Probe Temp, °F	Filter Temp, °F	Impinger Exit Temp, °F	Dry Gas Meter Temperature, °F	Pump Vacuum, in. Hg																																																																																																															
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Project Information Date <u>1-11-22</u> Project # <u>PR05-010216</u> Customer/Facility <u>Bloom Energy</u> Unit ID/Sample Location <u>YUMA Ambient</u> Run # <u>3-PM-Ambient</u> Operator <u>RV</u>				Sampling Conditions Static Pressure, in. H ₂ O <u>—</u> Ambient Temp, °F <u>60</u> Barometric Pressure, in. Hg <u>30.20</u> Ref. Barometer ID <u>LOCAL</u> Wind Speed / Direction <u>0MPH</u> Precipitation, Y/N type <u>—</u> Probe / Filter Temp Range, °F <u>—</u>				ALT 011 TC ID: <u>—</u> Ambient °F <u>—</u> Ref. °F <u>—</u> Stack <u>—</u> Probe <u>—</u> Filter Box <u>—</u> Filter Exit <u>—</u> Meter outlet <u>CB-23</u> <u>60</u> <u>59.9</u> Impinger Exit <u>CSM-5</u> <u>60</u> <u>59.9</u> Other <u>—</u> Ref. Thermometer ID <u>T4108</u> Continuity Check ☒ Continuity w/ Proper Polarity Notes: <u>—</u>						
Sampling Equipment IDs Meterbox ID <u>CB-23</u> Umbilical ID <u>UL-201</u> Nozzle ID <u>—</u> Pitot / Probe ID <u>—</u> Manometer ID <u>CB-23</u> Sensitivity <u>0.01</u>		Calibration Meterbox Y <u>0.985</u> Meterbox ΔH@, in. H ₂ O <u>1.853</u> Nozzle diameter, Dn, in. <u>—</u> Pitot coefficient, Cp <u>0.84</u> Manometer zero and level ☒ yes K-Factor <u>ΔH=1.5</u>		Equipment Checks Pitot (+), pass @ in. H ₂ O ☐ @ ☐ @ ☐ @ Pitot (-), pass @ in. H ₂ O ☐ @ ☐ @ ☐ @ Pitot visual inspection ☐ pass ☐ pass ☐ pass Nozzle visual inspection ☐ pass ☐ pass ☐ pass Meter, cfm @ in. Hg <u>0.008 @ 17</u> <u>—</u> @ <u>—</u> <u>0.008 @ 17</u> Intermediate leak check volume, ft ³ <u>—</u> / <u>—</u>										
Traverse Point #	Elapsed Time	Clock Time 24hr	DGM Reading, Vm, ft ³ /min	Velocity Head, ΔP in H ₂ O	Orifice Pressure Differential, ΔH		Stack Temp, °F	Probe Temp, °F	Filter Temp, °F		Impinger Exit Temp, °F	Dry Gas Meter Temperature, °F		Pump Vacuum, in. Hg
					Target	Actual			Box	Exit		Inlet	Outlet	
1	0	1007	40.98	1.5	1.5	1.5	1.5	60	60	60	60	60	60	14
2	10	1017	40.97	1.5	1.5	1.5	1.5	60	60	60	60	60	60	14
3	20	1027	41.5	1.5	1.5	1.5	1.5	60	60	60	60	60	60	14
4	30	1037	42.2	1.5	1.5	1.5	1.5	60	60	60	60	60	60	14
5	40	1047	42.9	1.5	1.5	1.5	1.5	60	60	60	60	60	60	14
6	50	1057	43.5	1.5	1.5	1.5	1.5	60	60	60	60	60	60	14
7	60	1107	44.2	1.5	1.5	1.5	1.5	60	60	60	60	60	60	14
8	—	60	40.037	1.5	1.5	1.5	1.5	60	60	60	60	60	60	14



Sample Recovery & Calibration Check Datasheet

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Project Information Date <u>1-11-21</u> Project # <u>PROS-012216</u> Customer / Facility <u>Bloom Energy</u> Unit ID / Sample Location <u>Yuma Ambient</u> Run # <u>1-3-PM-Ambient</u> Operator <u>RV</u>				Equipment Identification Ref. Thermometer <u>-</u> Hygrometer <u>-</u> Field Balance <u>18-AB-0A-T8</u> Check Weights <u>W-10</u> Calipers <u>-</u>						
Balance Audit (Field balance must be within 0.5g of check weight mass) Date <u>1/11/21</u> Standard mass, g <u>5005</u> Field balance mass, g <u>499.85</u>				Ambient Conditions (Mobile Lab) Relative humidity, % <u>-</u> Temperature, °F <u>60</u> Mobile lab # <u>T8</u>						
Moisture Determination										
		Run 1			Run 2			Run 3		
Contents	Initial	Final	Net	Initial	Final	Net	Initial	Final	Net	
Knockout	MT 613.1	611.6	-1.5	642.1	640.0	-2.1	633.4	628.6	-4.8	
Impinger 1	MT 718.5	716.4	-2.1	629.4	628.0	-1.4	660.5	658.4	-2.1	
Impinger 2	Don't Know 619.2	615.4	-3.8	589.1	584.4	-4.7	683.8	677.4	-6.4	
Impinger 3	SIGel 887.7	899.1	11.4	910.0	922.1	12.1	924.6	938.7	14.1	
Impinger 4										
Impinger 5										
Impinger 6										
Impinger 7										
Impinger 8										
Silica Gel										
Line Rinse										
Train Net Gain (Vlc)			<u>4.0</u>				<u>3.9</u>	<u>-10.4</u>		
Nozzle Measurements (Difference between any two measurements must not be more than 0.004 in (0.1 mm))										
Nozzle 1 diameters	<u>-</u> D1	<u>-</u> D2	<u>-</u> D3	Average <u>-</u>						
Nozzle 2 diameters	<u>-</u> D1	<u>-</u> D2	<u>-</u> D3	Average <u>-</u>						
Nozzle 3 diameters	<u>-</u> D1	<u>-</u> D2	<u>-</u> D3	Average <u>-</u>						
Nozzle Material	quartz	glass	steel	titanium	inconel	other <u>Cassette Filter N/A</u>				
Probe Type	heated	unheated	air-cooled	water-cooled	other <u>N/A</u>					
Probe Liner	quartz	glass	steel	Teflon	other <u>N/A</u>					
Filter Information										
Front Half:	quartz fiber	glass fiber	Teflon	Teflon/quartz	other <u>Cassette Filter</u>					
Filter Number:	Run 1: <u>378</u>	Run 2: <u>709</u>	Run 3: <u>621</u>	Run : <u>-</u>						
Back Half:	quartz fiber	glass fiber	Teflon	Teflon/quartz	other <u>N/A</u>					
Reagent Information					Sample Observations					
Type	<u>N/A</u>				<u>N/A</u>					
Lot Number										

QA/QC Check: Completeness ___ Legibility ___ Accuracy ___ Specifications ___

Checked by: _____ Team Leader: _____

001AS-QMS-FM-226

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Appendix A.3

Particulate Matter Calculations/Results

SOURCE TEST DATA SUMMARY				
EPA METHOD 5/202				
Client.....	Bloom Energy			
Unit / Location.....	Yuma			
A (stack area), ft ²	0.196			
T _{ref} (reference temperature), °F.....	60			
Test number.....	1	2	3	Average
Date.....	1/11/22	1/11/22	1/11/22	--
Start / Stop time.....	1907-2009	2038-2140	2207-2309	--
Production Data				
Energy produced (D/C), kW (reported by facility).....	55.6	55.6	55.6	55.6
Meter box number.....	CB-10	CB-10	CB-10	--
C _p (pitot coefficient), dimensionless	0.8400	0.8400	0.8400	0.8400
Y (meter calibration factor), dimensionless.....	1.004	1.004	1.004	1.004
Θ (sample time), min.....	60.00	60.00	60.00	60.00
Nozzle diameter, in.....	0.350	0.350	0.350	0.350
A _n (cross-sectional area of nozzle), ft ²	0.001	0.001	0.001	0.001
P _{bar} (barometric pressure), in Hg.....	30.20	30.20	30.20	30.20
V _m (meter box volume), acf.....	34.503	33.720	33.997	34.073
V _{ic} (impinger liquid), g.....	69.4	71.1	73.8	71.4
T _m (meter temperature), °F.....	58.3	56.4	55.3	56.6
ΔH (meter pressure), in. H ₂ O.....	1.088	1.033	1.033	1.051
ΔP (velocity head), in. H ₂ O.....	0.1050	0.1015	0.1016	0.1027
P _g (static pressure), in. Hg.....	-0.05	-0.05	-0.05	-0.05
T _s (stack temperature), °F.....	551	548	545	548
%O ₂ (oxygen stack gas), % volume dry.....	20.90	20.90	20.90	20.90
%CO ₂ (carbon dioxide stack gas), % volume dry.....	<0.1	<0.1	<0.1	<0.1
PM				
m _{nf} (F½ particulate matter catch - combined), mg.....	0.49	0.70	0.79	0.66
m _{nb} (B½ particulate matter catch - combined), mg.....	1.24	2.33	1.24	1.60
m _n (total particulate matter catch - combined), mg.....	1.73	3.03	2.03	2.26
V _{m(std)} (standard sample volume), dscf.....	35.176	34.498	34.857	34.844
V _{w(std)} (water vapor volume), scf.....	3.223	3.302	3.427	3.317
B _{ws} (moisture fraction), non-dimensional.....	0.0839	0.0873	0.0895	0.0869
B _{ws} (moisture fraction saturated), non-dimensional.....	NA	NA	NA	#DIV/0!
B _{ws} (moisture fraction applicable), non-dimensional.....	0.0839	0.0873	0.0895	0.0869
Moisture, %.....	8.4	8.7	9.0	8.7
MW _{dry} (stack gas molecular weight), dry.....	28.852	28.852	28.852	28.852
MW _{wet} (stack gas molecular weight), wet.....	27.941	27.904	27.881	27.909
P _s (absolute stack pressure), in Hg.....	30.196	30.196	30.196	30.196
V _s (stack gas velocity), ft/sec.....	25.477	25.026	25.012	25.172
Q _{sw} (stack flow rate), wscf/hr.....	9,347	9,209	9,231	9,262
Q _{sd} (stack flow rate), dscf/hr.....	8,563	8,405	8,405	8,457
Q (stack flow rate), acfm.....	300	295	295	297
Q _{ws} (stack flow rate), wscfm.....	156	153	154	154
Q _{ds} (stack flow rate), dscfm.....	143	140	140	141
G (F½ grain loading), gr/dscf.....	0.00021	0.00031	0.00035	0.00029
M (F½ mass emissions), lb/hr.....	0.00026	0.00038	0.00042	0.00035
E (F½ mass emissions), lb/MW-hr.....	0.0047	0.0068	0.0075	0.0063
G (B½ grain loading), gr/dscf.....	0.00054	0.00104	0.00055	0.00071
M (B½ mass emissions), lb/hr.....	0.00066	0.00125	0.00066	0.00086
E (B½ mass emissions), lb/MW-hr.....	0.012	0.022	0.012	0.015
G (total grain loading), gr/dscf.....	0.00076	0.00135	0.00090	0.00100
M (total mass emissions), lb/hr.....	0.00093	0.00162	0.00108	0.00121
E (Total mass emissions), lb/MW-hr.....	0.017	0.029	0.019	0.022

SOURCE TEST DATA SUMMARY

EPA METHOD 5/202

Client.....	Bloom Energy			
Unit / Location.....	Yuma Ambient			
A (stack area), ft ²	0.196			
T _{ref} (reference temperature), °F.....	70			
Test number.....	1	2	3	Average
Date.....	1/11/22	1/11/22	1/12/22	--
Start / Stop time.....	1907-2007	2038-2138	2207-2307	--
Meter box number.....	CB-23	CB-23	CB-23	--
C _p (pitot coefficient), dimensionless	0.8400	0.8400	0.8400	0.8400
Y (meter calibration factor), dimensionless.....	0.985	0.985	0.985	0.985
Ø (sample time), min.....	60.00	60.00	60.00	60.00
P _{bar} (barometric pressure), in Hg.....	30.02	30.20	30.20	30.14
V _m (meter box volume), acf.....	40.672	41.968	40.037	40.892
V _{ic} (impinger liquid), g.....	4.0	3.9	-10.4	-0.8
T _m (meter temperature), °F.....	62.5	62.5	61.5	62.2
ΔH (meter pressure), in. H ₂ O.....	1.500	1.500	1.500	1.500
%O ₂ (oxygen stack gas), % volume dry.....	20.9	20.9	20.9	20.9
%CO ₂ (carbon dioxide stack gas), % volume dry.....	<0.1	<0.1	<0.1	<0.1
PM				
m _{nf} (F½ particulate matter catch - combined), mg.....	0.036	0.044	0.045	0.042
V _{m(std)} (standard sample volume), dscf.....	40.923	42.479	40.602	41.334
V _{w(std)} (water vapor volume), scf.....	0.189	0.185	-0.492	-0.039
B _{ws} (moisture fraction), non-dimensional.....	0.0046	0.0043	-0.0123	-0.0011
B _{ws} (moisture fraction saturated), non-dimensional.....	0.0015	0.0015	0.0015	0.0015
B _{ws} (moisture fraction applicable), non-dimensional.....	0.0015	0.0015	-0.0123	-0.0031
Moisture, %.....	0.15	0.15	-1.23	-0.31
MW _{dry} (stack gas molecular weight), dry.....	28.852	28.852	28.852	28.852
MW _{wet} (stack gas molecular weight), wet.....	28.836	28.836	28.985	28.886
P _s (absolute stack pressure), in Hg.....	30.020	30.200	30.200	30.140
G (F½ grain loading), gr/dscf.....	0.000014	0.000016	0.000017	0.000016

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Appendix A.4

Example Calculations



EXAMPLE CALCULATIONS STACK GAS VOLUMETRIC FLOW RATE

Project name: Bloom Energy
 Computed by: Pswitzer
 Run number: 1

Project number: PROJ-012216
 Calculation date: 2022-02-23

SAMPLE TRAIN DATA

Meter calibration factor, Y_d	<u>1.004</u>	Y
Stack area, square feet	<u>0.196</u>	A_s
Pitot Coefficient	<u>0.84</u>	C_p
Barometric pressure, in. Hg	<u>30.20</u>	P_{bar}
Meter box volume, acf	<u>34.503</u>	V_m
Impinger liquid volume, g	<u>69.4</u>	V_{lc}
Meter temperature, °R	<u>518.3</u>	$T_m = (°F \text{ plus } 460)$
Meter pressure, (delta H) iwg	<u>1.088</u>	ΔH
Velocity head, (delta P) iwg	<u>0.105</u>	ΔP
Static pressure, iwg	<u>-0.05</u>	P_{sg}
Stack temperature, °R	<u>1011</u>	$T_s = (°F \text{ plus } 460)$
Stack O ₂ , % volume dry	<u>20.9</u>	O_2
Stack CO ₂ , % volume dry	<u>0</u>	CO_2
Stack N ₂ , % volume dry	<u>79.1</u>	$N_2 = (100 - \%O_2 - \%CO_2)$
Nozzle area, square feet	<u>0.000668</u>	$A_n = \pi (D_n / 2)^2 (1 \text{ ft} / 12 \text{ in})^2$
PM sampling time, minutes	<u>60</u>	Θ
Reference temperature, °R	<u>530</u>	$T_{std} = (°F \text{ plus } 460)$

Note: The results calculated in the pages that follow may differ slightly from the results presented in the final report. This difference can be attributed to "significant digit round-off errors" common when comparing computer spreadsheets results with those derived from using a calculator.



1 VOLUMETRIC FLOW RATE

a. Standard sample gas volume, dscf

$$V_{m\ std} = (V_m)(Y) \frac{(T_{std}) \left[P_{bar} + \left(\frac{\Delta H}{13.6} \right) \right]}{(T_m) (P_{std})}$$

$$V_{m\ std} = \frac{(34.503)(1.004)(530)[30.2 + (1.088)/(13.6)]}{(518.3)(29.92)}$$

$$V_{m\ std} = \underline{35.849} \text{ dscf}$$

b. Water vapor volume, scf

$$V_{w\ std} = (0.04715)(V_{lc}) \left(\frac{T_{std}}{528} \right)$$

$$V_{w\ std} = \frac{(0.04715)(69.4)(530)}{(528)}$$

$$V_{w\ std} = \underline{3.285} \text{ scf}$$

c. Moisture content, non-dimensional

$$B_{ws} = \left(\frac{V_{w\ std}}{V_{m\ std} + V_{w\ std}} \right)$$

$$B_{ws} = \frac{(3.285)}{(35.849 + 3.285)}$$

$$B_{ws} = \underline{0.0839} \text{ moisture content (multiply by 100 for \% by volume)}$$

**d. Stack gas molecular weight, lb/lb mole (dry)**

$$MW_{dry} = [0.44(\%CO_2)] + [0.32(\%O_2)] + [0.28(\%N_2)]$$

$$MW_{dry} = [0.44(0)] + [0.32(20.9)] + [0.28(79.1)]$$

$$MW_{dry} = \underline{28.836} \text{ lb/lb mole}$$

e. Stack gas molecular weight, lb/lb mole (wet)

$$MW_{wet} = [MW_{dry}(1-B_{ws})] + [18(B_{ws})]$$

$$MW_{wet} = [28.836(1-0.0839)] + [18(0.0839)]$$

$$MW_{wet} = \underline{27.927} \text{ lb/lb mole}$$

f. Absolute stack pressure, in Hg

$$P_s = P_{bar} + \left(\frac{P_{sg}}{13.6} \right)$$

$$P_s = 30.2 + (-0.05/13.6)$$

$$P_s = \underline{30.196} \text{ in. Hg}$$

g. Stack velocity, ft/sec

$$v_s = (85.49)(C_p)(\sqrt{\Delta P}) \sqrt{\frac{T_s}{(P_s)(MW_{wet})}}$$

$$v_s = (85.49)(0.84) \sqrt{\frac{(0.105)(1011)}{(30.196)(27.927)}}$$

$$v_s = \underline{25.479} \text{ ft/sec}$$

**h. Actual stack flow rate, acfm**

$$Q = (v_s)(A_s)(60 \text{ min/hr})$$

$$Q = (25.479)(0.196)(60)$$

$$Q = \underline{300} \text{ acfm}$$

i. Standard stack gas flow rate, wscfm

$$Q_{ws} = (v_s)(A_s)(60 \text{ min/hr}) \left(\frac{T_{std}}{T_s} \right) \left(\frac{P_s}{P_{std}} \right)$$

$$Q_{ws} = (25.479)(0.196)(60)(530/1011)(30.196/29.92)$$

$$Q_{ws} = \underline{159} \text{ wscfm}$$

j. Standard stack gas flow rate, dscfm

$$Q_{ds} = (v_s)(A_s)(60 \text{ min/hr})(1 - B_{ws}) \left(\frac{T_{std}}{T_s} \right) \left(\frac{P_s}{P_{std}} \right)$$

$$Q_{ds} = (25.479)(0.196)(60)(1 - 0.0839)(530/1011)(30.196/29.92)$$

$$Q_{ds} = \underline{145} \text{ dscfm}$$



EXAMPLE CALCULATIONS PARTICULATE MATTER EMISSIONS

Project name: Bloom Energy
 Computed by: P Switzer
 Run number: 1

Project number: PROJ-12216A
 Calculation date: 2022-02-23

EMISSIONS DATA

Mass of collected particulate matter, mg	<u>1.73</u>	G_m
Dry stack gas flow rate at standard conditions, dscfm	<u>143</u>	Q_{ds}
Dry meter volume at standard conditions, dscf	<u>35.176</u>	$V_{m\ std}$
Stack O ₂ , % volume dry	<u>20.90</u>	O_2

1 PARTICULATE MATTER EMISSIONS

a. Grain loading, gr/dscf

$$G = (0.0154) \left(\frac{G_m}{V_{m\ std}} \right)$$

$$G = (0.0154) \frac{(1.73)}{(35.176)}$$

$$G = \underline{0.0008} \text{ gr/dscf}$$

Note: The results calculated in the pages that follow may differ slightly from the results presented in the final report. This difference can be attributed to "significant digit round-off errors" common when comparing computer spreadsheets results with those derived from using a calculator.



c. Mass emission rate, lb/hr

$$M = (G)(Q_{ds}) \frac{(60 \text{ min/hr})}{(7,000 \text{ gr/lb})}$$

$$M = \frac{(0.0008)(143)(60)}{(7,000)}$$

$$M = \underline{0.00093} \text{ lb/hr}$$

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Appendix A.5

General Equations

EMISSION CALCULATIONS

1. Volumetric Flow and Isokinetics

- a. Standard sample gas volume, dscf

$$V_{m\ std} = (V_m)(Y) \frac{(T_{std} + 460) \left(P_{bar} + \frac{\Delta H}{13.6} \right)}{(T_m + 460)(P_{std})}$$

- b. Water vapor volume, scf

$$V_{w\ std} = (0.04715)(V_{lc}) \left(\frac{T_{std} + 460}{528} \right)$$

- c. Moisture content, non-dimensional

$$B_{ws} = \frac{V_{w\ std}}{(V_{m\ std} + V_{w\ std})}$$

- d. Stack gas molecular weight, lb/lb mole (dry)

$$MW_{dry} = [0.44(\%CO_2)] + [0.32(\%O_2)] + [0.28(\%N_2)]$$

- e. Stack gas molecular weight, lb/lb mole (wet)

$$MW_{wet} = [MW_{dry}(1 - B_{ws})] + [18(B_{ws})]$$

- f. Absolute stack pressure, in Hg

$$P_s = P_{bar} + \left(\frac{P_{sg}}{13.6} \right)$$

- g. Stack velocity, ft/sec

$$v_s = (85.49)(C_p)(\sqrt{\Delta P}) \sqrt{\frac{T_s}{(P_s)(MW_{wet})}}$$

- h. Actual stack flow rate, acfm

$$Q = (v_s)(A_s)(60\ min/hr)$$

- i. Standard stack gas flow rate, wscfm

$$Q_{ws} = (v_s)(A_s)(60\ min/hr) \left(\frac{T_{std} + 460}{T_s + 460} \right) \left(\frac{P_s}{P_{std}} \right)$$

- j. Standard stack gas flow rate, dscfm

$$Q_{ds} = (v_s)(A_s)(60\ min/hr)(1 - B_{ws}) \left(\frac{T_{std} + 460}{T_s + 460} \right) \left(\frac{P_s}{P_{std}} \right)$$

- k. Percent isokinetic

$$I = \frac{(T_s)(V_{m\ std})(P_{std})(100)}{(T_{std} + 460)(v_s)(\theta)(A_n)(P_s)(60)(1 - B_{ws})}$$

2. Gaseous Emissions

- a. Concentration, ppm volume wet (i.e. to calculate wet ppm from dry ppm)

$$C_w = (C)(1 - B_{ws})$$

- b. Concentration, ppm @ 3% O
- ₂
- dry

$$C_3 = (C) \left[\frac{(20.9 - 3.0)}{(20.9 - \% O_2)} \right]$$

- c. Concentration, ppm @ 12% CO
- ₂
- dry

$$C_{12} = (C) \left(\frac{12.0}{\% CO_2} \right)$$

- d. Concentration, ppm volume dry (i.e. to calculate dry ppm from wet ppm)

$$C = \left[\frac{C_w}{(1 - B_{ws})} \right]$$

- e. Mass emission rate, lb/hr

$$M = (C)(CF)(Q_{ds})(60 \text{ min/hr})$$

where,

CF = conversion factor from ppm to lb/scf:

$$CF_{NOx} = 1.194 \times 10^{-7} \left(\frac{\text{lb/scf}}{\text{ppm}} \right)$$

$$CF_{SO2} = 1.660 \times 10^{-7} \left(\frac{\text{lb/scf}}{\text{ppm}} \right)$$

$$CF_X = CF_{NOx} \left(\frac{MW_X}{MW_{NOx}} \right) \text{ for other compounds (x)}$$

- f. Emission rate, lb/MMBtu

$$E = (C)(CF)(F_d) \left(\frac{20.9}{20.9 - \% O_2} \right)$$

- g. Mass emission rate, grams/bhp-hr

$$M_j = (M) \left(\frac{453.59 \text{ g/lb}}{J} \right)$$

3. Particulate Emissions

- a. Grain loading, gr/dscf

$$G = (0.0154) \left(\frac{G_m}{V_{m\ std}} \right)$$

- b. Grain loading corrected to 12% CO
- ₂
- , gr/dscf @ 12% CO
- ₂

$$G_{12} = (G) \left(\frac{12.0}{\% CO_2} \right)$$

- c. Mass emission rate, lb/hr

$$M = (G)(Q_{ds}) \left(\frac{60\ min/hr}{7,000\ gr/lb} \right)$$

- d. Emission rate, lb/MMBtu

$$E = (G) \left(\frac{1\ lb}{7,000\ gr} \right) (F_d) \left(\frac{20.9}{20.9 - \% O_2} \right)$$

4. Fuel Factor "F"

- a. Choice #1 – use the values for F_d provided in Method 19, Table 19-1
 Choice #2 – if you have fuel ultimate and proximate analysis, calculate F_d
 (need fuel weight %CHONS, HHV)

Stoichiometric fuel factor at 68 °F, dscf/MMBtu at 0% O₂:

$$F_d = \frac{(10^6)[3.64(\% H) + 1.53(\% C) + 0.14(\% N) + 0.57(\% S) - 0.46(\% O)]}{HHV, Btu/lb}$$

- b. Fuel factor at 60 °F (use if all your volumes and flows are at 60 °F)

$$F_{d\ 60} = F_d \left(\frac{520^\circ R}{528^\circ R} \right)$$

5. Miscellaneous Equations

- a. Standard stack gas flow rate, calculated from fuel flow and F factor, dscfm

Note: Q_f and HHV need to be in units of either lb/hr and Btu/lb, or scf/hr and Btu/scf.
Do not mix units!

(calculation based on stack %O₂)

$$Q_{ds} = (Q_f)(HHV)(10^{-6})(F_d) \left(\frac{20.9}{20.9 - \% O_2} \right) / (60 \text{ min/hr})$$

or (calculation based on stack %CO₂ – see EPA Method 19 for values of F_c)

$$Q_{ds} = (Q_f)(HHV)(10^{-6})(F_c) \left(\frac{100}{\% CO_2} \right) / (60 \text{ min/hr})$$

- b. Destruction efficiency of emission control device, %

$$EFF = \left(\frac{C_{in} - C_{out}}{C_{in}} \right) (100\%) \quad \text{based on concentrations}$$

or

$$EFF = \left(\frac{M_{in} - M_{out}}{M_{in}} \right) (100\%) \quad \text{based on mass emission rates}$$

- c. Cylinder gas audit, % accuracy

$$A_c = \left(\frac{C_m - C_a}{C_a} \right) (100\%)$$

Nomenclature:

A_c	=	accuracy of CEMS during cylinder gas audit (CGA), % difference
A_n	=	nozzle area, in ² (πr^2), where $\pi = 3.1416$ and r = radius ($\frac{1}{2}$ diameter) in inches
A_s	=	stack area, ft ² (πr^2), where $\pi = 3.1416$ and r = radius ($\frac{1}{2}$ diameter) in feet
B_{ws}	=	flue gas moisture content (multiply by 100 for % by volume)
C	=	concentration of gaseous species, ppm volume dry
C_a	=	concentration of audit gas, ppm (for CGA, equation 5c)
C_m	=	concentration measured by CEMS, ppm (for CGA, equation 5c)
C_p	=	calibration factor for pitot tube, dimensionless
C_w	=	concentration of gaseous species, ppm volume wet
C_3	=	corrected concentration of gaseous species, ppm @ 3% O ₂ dry
C_{12}	=	corrected concentration of gaseous species, ppm @ 12% CO ₂ dry
E	=	mass emission rate, lb/MMBtu
EFF	=	destruction or removal efficiency of emission control device, % efficiency
F_c	=	stoichiometric "F" factor of fuel based on CO ₂ , dscf/MMBtu @ 100% CO ₂
F_d	=	stoichiometric "F" factor of fuel based on O ₂ , dscf/MMBtu @ 0% O ₂
G	=	particulate matter grain loading, grains/dscf
G_{12}	=	corrected particulate matter grain loading, grains/dscf @ 12% CO ₂
G_m	=	mass of collected particulate matter, mg
HHV	=	higher heating value, Btu/cubic foot
I	=	% isokinetic sampling rate, %
J	=	brake horsepower, bhp
M_j	=	mass emission rate of measured species (s), g/hp-hr
M	=	mass emission rate, lb/hr
MW_{dry}	=	molecular weight of stack gas, dry basis
MW_{wet}	=	molecular weight of stack gas, wet basis
MW_s	=	molecular weight of gaseous species (s), lb/lb mole:
		CO: 28.01 (can use 28) NO _x as NO ₂ : 46.01 (can use 46)
		SO _x as SO ₂ : 64.06 (can use 64) Hydrocarbons as C: 12.01 (can use 12)
		Hydrocarbons as CH ₄ : 16.04 (can use 16) Hydrocarbons as C ₃ H ₈ : 44.10 (can use 44)
		NH ₃ : 17.03 (can use 17)
N_2	=	nitrogen content of stack gas, % volume dry
P_{bar}	=	barometric pressure, in. Hg
P_s	=	stack absolute pressure, in. Hg
P_{sg}	=	stack static pressure, inches of water, gauge (iwg)
Q	=	wet stack gas flow rate at actual conditions, acfm
Q_f	=	fuel flow rate, scfh or lb/hr (be careful of units)
Q_{ds}	=	dry stack gas flow rate at standard conditions, dscfm
Q_{ws}	=	wet stack gas flow rate at standard conditions, wscfm
SV	=	specific molar volume of an ideal gas at standard conditions, ft ³ /lb mole
T_m	=	meter temperature, °R
T_{std}	=	reference temperature, °R
T_s	=	stack gas temperature, °R
v_s	=	stack gas velocity, ft/sec
V_{lc}	=	volume of liquid collected in impingers, ml
V_m	=	dry meter volume uncorrected, acf
$V_{m\ std}$	=	dry meter volume corrected to standard conditions, dscf
$V_{w\ std}$	=	volume of water vapor at standard conditions, scf
Y	=	meter calibration coefficient, dimensionless
ΔH	=	average pressure differential across meter, inches water
ΔP	=	average velocity head of stack gas, inches water
Θ	=	sampling time, minutes

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APPENDIX B FACILITY PROCESS DATA

Location	Date/Time	Kw AC	Kw DC	AVG Stack Temp	Total Fuel Flow	Total Air flow (slm)	Seg-1 Current	Seg-2 Current	Seg-3 Current	Seg-4 Current	Seg-1 Voltage	Seg-2 Voltage	Seg-3 Voltage	Seg-4 Voltage
MOF000.22.D	01/11/2022 19:00	51.06	55.58	782.6207886	145.916275	3790.362549	36.48999786	36.5	36.48999786	36.5	398	398	398	398
MOF000.22.D	01/11/2022 19:05	51.05	55.58	782.6260376	145.9286041	3811.13623	36.48999786	36.5	36.48999786	36.5	398.0999756	398.0999756	398.0999756	398.0999756
MOF000.22.D	01/11/2022 19:10	51.06	55.58	782.6312866	145.9902496	3800.749268	36.48999786	36.5	36.48999786	36.5	398.0999756	398.0999756	398.0999756	398.0999756
MOF000.22.D	01/11/2022 19:15	51.06	55.58	782.6365356	145.9470978	3785.168701	36.48999786	36.5	36.48999786	36.5	398.0999756	398.0999756	398.0999756	398.0999756
MOF000.22.D	01/11/2022 19:20	51.06	55.58	782.6417847	145.9039459	3805.943115	36.48999786	36.5	36.48999786	36.5	398.0999756	398.0999756	398.0999756	398.0999756
MOF000.22.D	01/11/2022 19:25	51.06	55.58	782.6470337	145.8607941	3803.345947	36.48999786	36.5	36.48999786	36.5	398.0999756	398.0999756	398.0999756	398.0999756
MOF000.22.D	01/11/2022 19:30	51.06	55.58	782.6522827	145.8299866	3779.975586	36.48999786	36.5	36.48999786	36.5	398.0999756	398.0999756	398.0999756	398.0999756
MOF000.22.D	01/11/2022 19:35	51.06	55.58	782.6575317	145.971756	3787.765137	36.48999786	36.5	36.48999786	36.5	398.0999756	398.0999756	398.0999756	398.0999756
MOF000.22.D	01/11/2022 19:40	51.05	55.58	782.6627808	145.8176575	3774.781738	36.48999786	36.5	36.48999786	36.5	398.0999756	398.0999756	398.0999756	398.0999756
MOF000.22.D	01/11/2022 19:45	51.05	55.58	782.6680298	146.1628418	3785.168701	36.48999786	36.5	36.48999786	36.5	398.0999756	398.0999756	398.0999756	398.0999756
MOF000.22.D	01/11/2022 19:50	51.05	55.58	782.6733398	145.9409332	3792.958984	36.48999786	36.5	36.48999786	36.5	397.7999878	397.7999878	397.7999878	397.7999878
MOF000.22.D	01/11/2022 19:55	51.06	55.58	782.6785889	145.8361511	3779.975586	36.48999786	36.5	36.48999786	36.5	397.7999878	397.7999878	397.7999878	397.7999878
MOF000.22.D	01/11/2022 20:00	51.06	55.58	782.6838379	145.971756	3785.168701	36.48999786	36.5	36.48999786	36.5	397.8999939	397.8999939	397.8999939	397.8999939
MOF000.22.D	01/11/2022 20:05	51.06	55.58	782.6890869	145.9902496	3774.781738	36.48999786	36.5	36.48999786	36.5	397.8999939	397.8999939	397.8999939	397.8999939
MOF000.22.D	01/11/2022 20:10	51.07	55.58	782.6943359	145.9594269	3761.797607	36.48999786	36.5	36.48999786	36.5	397.8999939	397.8999939	397.8999939	397.8999939
MOF000.22.D	01/11/2022 20:15	51.07	55.58	782.699585	145.9409332	3777.378418	36.48999786	36.5	36.48999786	36.5	398.1999817	398.1999817	398.1999817	398.1999817
MOF000.22.D	01/11/2022 20:20	51.08	55.58	782.704834	145.8977814	3779.975586	36.48999786	36.5	36.48999786	36.5	397.8999939	397.8999939	397.8999939	397.8999939
MOF000.22.D	01/11/2022 20:25	51.09	55.58	782.710083	145.916275	3766.991455	36.48999786	36.5	36.48999786	36.5	397.8999939	397.8999939	397.8999939	397.8999939
MOF000.22.D	01/11/2022 20:30	51.09	55.58	782.7160645	145.9594269	3754.007324	36.48999786	36.5	36.48999786	36.5	397.8999939	397.8999939	397.8999939	397.8999939
MOF000.22.D	01/11/2022 20:35	51.07	55.58	782.723999	145.8484802	3761.797607	36.48999786	36.5	36.48999786	36.5	398	398	398	398
MOF000.22.D	01/11/2022 20:40	51.09	55.58	782.7319946	145.8176575	3772.185303	36.48999786	36.5	36.48999786	36.5	398	398	398	398
MOF000.22.D	01/11/2022 20:45	51.08	55.58	782.7399292	145.9655914	3779.975586	36.48999786	36.5	36.48999786	36.5	398.1999817	398.1999817	398.1999817	398.1999817
MOF000.22.D	01/11/2022 20:50	51.08	55.58	782.7479248	145.7375183	3772.185303	36.48999786	36.5	36.48999786	36.5	398.1999817	398.1999817	398.1999817	398.1999817
MOF000.22.D	01/11/2022 20:55	51.07	55.58	782.7558594	145.7313538	3759.201172	36.48999786	36.5	36.48999786	36.5	397.8999939	397.8999939	397.8999939	397.8999939
MOF000.22.D	01/11/2022 21:00	51.07	55.58	782.763855	145.8299866	3795.555664	36.48999786	36.5	36.48999786	36.5	397.8999939	397.8999939	397.8999939	397.8999939
MOF000.22.D	01/11/2022 21:05	51.08	55.58	782.7717896	145.9964142	3790.362549	36.48999786	36.5	36.48999786	36.5	397.8999939	397.8999939	397.8999939	397.8999939
MOF000.22.D	01/11/2022 21:10	51.07	55.58	782.7797852	145.9532623	3774.781738	36.48999786	36.5	36.48999786	36.5	397.7999878	397.7999878	397.7999878	397.7999878
MOF000.22.D	01/11/2022 21:15	51.08	55.58	782.7877197	145.756012	3785.168701	36.48999786	36.5	36.48999786	36.5	398	398	398	398
MOF000.22.D	01/11/2022 21:20	51.07	55.58	782.7957153	145.9532623	3764.394775	36.48999786	36.5	36.48999786	36.5	398	398	398	398
MOF000.22.D	01/11/2022 21:25	51.08	55.58	782.8036499	145.9286041	3785.168701	36.48999786	36.5	36.48999786	36.5	398	398	398	398
MOF000.22.D	01/11/2022 21:30	51.09	55.58	782.8116455	145.9532623	3761.797607	36.48999786	36.5	36.48999786	36.5	398	398	398	398
MOF000.22.D	01/11/2022 21:35	51.09	55.58	782.8195801	145.8607941	3751.410889	36.48999786	36.5	36.48999786	36.5	398	398	398	398
MOF000.22.D	01/11/2022 21:40	51.1	55.58	782.8275757	145.6943665	3754.007324	36.48999786	36.5	36.48999786	36.5	398	398	398	398
MOF000.22.D	01/11/2022 21:45	51.09	55.58	782.8355103	145.9840851	3746.217529	36.48999786	36.5	36.48999786	36.5	398	398	398	398
MOF000.22.D	01/11/2022 21:50	51.1	55.6	782.8435059	145.8114929	3766.991455	36.48999786	36.5	36.48999786	36.5	398	398	398	398
MOF000.22.D	01/11/2022 21:55	51.1	55.6	782.8514404	145.7929993	3761.797607	36.48999786	36.5	36.48999786	36.5	398	398	398	398
MOF000.22.D	01/11/2022 22:00	51.1	55.6	782.859436	146.1011963	3759.201172	36.48999786	36.5	36.48999786	36.5	398	398	398	398
MOF000.22.D	01/11/2022 22:05	51.1	55.6	782.8673706	145.7251892	3764.394775	36.48999786	36.5	36.48999786	36.5	398	398	398	398
MOF000.22.D	01/11/2022 22:10	51.11	55.6	782.8753662	145.7868347	3756.604492	36.48999786	36.5	36.48999786	36.5	398	398	398	398
MOF000.22.D	01/11/2022 22:15	51.11	55.6	782.8833008	145.7498474	3746.217529	36.48999786	36.5	36.48999786	36.5	398	398	398	398
MOF000.22.D	01/11/2022 22:20	51.12	55.6	782.8912964	145.9840851	3741.023926	36.48999786	36.5	36.48999786	36.5	398	398	398	398
MOF000.22.D	01/11/2022 22:25	51.12	55.6	782.899231	145.7868347	3751.410889	36.48999786	36.5	36.48999786	36.5	398.0999756	398.0999756	398.0999756	398.0999756
MOF000.22.D	01/11/2022 22:30	51.12	55.6	782.9072266	145.9840851	3743.620361	36.48999786	36.5	36.48999786	36.5	398.0999756	398.0999756	398.0999756	398.0999756
MOF000.22.D	01/11/2022 22:35	51.11	55.6	782.9151611	146.132019	3748.814209	36.48999786	36.5	36.48999786	36.5	398.0999756	398.0999756	398.0999756	398.0999756
MOF000.22.D	01/11/2022 22:40	51.12	55.6	782.9231567	145.916275	3738.427246	36.48999786	36.5	36.48999786	36.5	398.0999756	398.0999756	398.0999756	398.0999756
MOF000.22.D	01/11/2022 22:45	51.11	55.6	782.9310913	145.8669586	3754.007324	36.48999786	36.5	36.48999786	36.5	398.0999756	398.0999756	398.0999756	398.0999756
MOF000.22.D	01/11/2022 22:50	51.11	55.6	782.9390869	145.9655914	3725.443115	36.48999786	36.5	36.48999786	36.5	398.0999756	398.0999756	398.0999756	398.0999756
MOF000.22.D	01/11/2022 22:55	51.12	55.6	782.9470215	145.9470978	3751.410889	36.48999786	36.5	36.48999786	36.5	398.0999756	398.0999756	398.0999756	398.0999756
MOF000.22.D	01/11/2022 23:00	51.11	55.6	782.9550171	145.8792877	3738.427246	36.48999786	36.5	36.48999786	36.5	398.0999756	398.0999756	398.0999756	398.0999756
MOF000.22.D	01/11/2022 23:05	51.1	55.6	782.9629517	145.9224396	3743.620361	36.48999786	36.5	36.48999786	36.5	398.0999756	398.0999756	398.0999756	398.0999756
MOF000.22.D	01/11/2022 23:10	43.14	55.6	782.9709473	145.8669586	3761.797607	36.48999786	36.5	36.48999786	36.5	398.0999756	398.0999756	398.0999756	398.0999756
MOF000.22.D	01/11/2022 23:15	7.45	36.93	784.9404907	93.17819977	2477.074707	23.08999825	23.08999825	23.09999847	23.08999825	417	417	417	417

Bloom Energy
2022 Engineering Source Test Report

APPENDIX C

LABORATORY ANALYSIS DATA

Bloom Energy
2022 Engineering Source Test Report

Appendix C.1

Particulate Matter Analyses – Source



PARTICULATE MATTER RESULTS - EPA 5/202

Client: Bloom Energy Sunnyvale

Project: PROJ - 012216

Test No.:	1-PM	2-PM	3-PM
Front-Half Particulate Catch			
m_f Filter catch, net mg	0.33	< 0.28	< 0.28
m_a Probe / nozzle rinse (acetone), net mg	0.16	0.42	0.51
<i>Total filterable particulate matter catch, net mg</i>	<i>0.49</i>	<i>0.70</i>	<i>0.79</i>
Back-Half Particulate Catch			
m_i Aqueous rinse (ASTM Type II water), net mg	0.73	2.43	0.60
m_o Organic rinse (hexane and acetone), net mg	0.74	0.81	1.02
<i>Uncorrected condensible particulate matter catch, net mg</i>	<i>1.47</i>	<i>3.24</i>	<i>1.62</i>
Back-Half Blank Catch			
m_{ib} Field blank aqueous rinse (ASTM Type II water), net mg	0.51	0.51	0.51
m_{ob} Field blank organic rinse (hexane and acetone), net mg	0.40	0.40	0.40
m_{jb} <i>Total condensible particulate matter blank catch, net mg</i>	<i>0.91</i>	<i>0.91</i>	<i>0.91</i>
m_{cpm} <i>Corrected condensible particulate matter catch, net mg</i>	< 1.24	2.33	< 1.24
Total Particulate Matter Catch, net mg	1.73	3.03	2.03

Notes: The front-half acetone fractions were blank-corrected according to EPA Methods 5 / 17.

The back-half fractions were blank corrected according to EPA Method 202

The back-half fractions blank correction values is ($m_{ib} + m_{ob}$) or 2.0mg, whichever is lesser, according to EPA Method 202

Prepared by: 
 Esha Chetty
 Laboratory Manager

Date: 01 / 24 / 2022

Reviewed by: 
 Katie Resch
 QC/Reporting Specialist

Date: 01 / 24 / 2022

PARTICULATE MATTER RESULTS - EPA 5/202
Client: Bloom Energy Sunnyvale
Project: PROJ - 012216

Test Number	Sample Fraction	Sample Amount (g)	Lab Number (ID)	Tare Sequence (#)	Tare Weight (g)	Final Weight (g)	Raw Gain Weight (mg)	Blank Residue (%)	Blank Correction (mg)	Maximum Correction (mg)	Final Results (mg)
FRB-PM	Filter (F½)	N/A	2284	Tare 1	0.3099	0.3100	--	--	--	--	--
				Tare 2	0.3099	0.3100	--	--	--	--	--
				Tare 3	0.3098	0.3100	--	--	--	--	--
				Average	0.3099	0.3100	0.13	N/A	N/A	N/A	N/A
1-PM	Filter (F½)	N/A	2326	Tare 1	0.3020	0.3023	--	--	--	--	--
				Tare 2	0.3019	0.3023	--	--	--	--	--
				Tare 3	0.3019	0.3022	--	--	--	--	--
				Average	0.3019	0.3023	0.33	N/A	N/A	N/A	0.33
2-PM	Filter (F½)	N/A	2331	Tare 1	0.2994	0.2996	--	--	--	--	--
				Tare 2	0.2993	0.2997	--	--	--	--	--
				Tare 3	0.2994	0.2995	--	--	--	--	--
				Average	0.2994	0.2996	0.23	N/A	N/A	N/A	0.23
3-PM	Filter (F½)	N/A	2285	Tare 1	0.3132	0.3133	--	--	--	--	--
				Tare 2	0.3132	0.3133	--	--	--	--	--
				Tare 3	0.3131	0.3133	--	--	--	--	--
				Average	0.3132	0.3133	0.13	N/A	N/A	N/A	0.13

Note: The filters were not blank-corrected according to EPA Methods 5 / 17.

FRB-PM	Probe/Nozzle Acetone (F½)	128.7	AA054	Tare 1	2.24088	2.24112	--	--	--	--	--
				Tare 2	2.24080	2.24122	--	--	--	--	--
				Tare 3	2.24082	2.24123	--	--	--	--	--
				Average	2.24083	2.24119	0.36	0.0003%	N/A	N/A	N/A
1-PM	Probe/Nozzle Acetone (F½)	144.0	AA055	Tare 1	2.21922	2.21966	--	--	--	--	--
				Tare 2	2.21914	2.21982	--	--	--	--	--
				Tare 3	2.21925	2.21982	--	--	--	--	--
				Average	2.21920	2.21977	0.56	0.0003%	0.40	1.44	0.16
2-PM	Probe/Nozzle Acetone (F½)	82.9	AA056	Tare 1	2.23245	2.23308	--	--	--	--	--
				Tare 2	2.23251	2.23311	--	--	--	--	--
				Tare 3	2.23238	2.23310	--	--	--	--	--
				Average	2.23245	2.23310	0.65	0.0003%	0.23	0.83	0.42
3-PM	Probe/Nozzle Acetone (F½)	45.7	AA057	Tare 1	2.22353	2.22415	--	--	--	--	--
				Tare 2	2.22355	2.22421	--	--	--	--	--
				Tare 3	2.22353	2.22416	--	--	--	--	--
				Average	2.22354	2.22417	0.64	0.0003%	0.13	0.46	0.51

Note: The acetone fractions were blank-corrected according to EPA Methods 5 / 17. Blank values of greater than 0.001 percent of the weight of acetone used cannot be subtracted from the sample weight.

PARTICULATE MATTER RESULTS - EPA 5/202**Client: Bloom Energy Sunnyvale****Project: PROJ - 012216**

Test Number	Sample Fraction	Sample Amount (g)	Lab Number (ID)	Tare Sequence (#)	Tare Weight (g)	Final Weight (g)	Raw Gain Weight (mg)	Blank Residue (%)	Final Results (mg)
FRB-PM	Organic Rinse (B½)	127.1	AA058	Tare 1	2.22410	2.22441	--	--	--
				Tare 2	2.22403	2.22445	--	--	--
				Tare 3	2.22401	2.22448	--	--	--
				Average	2.22405	2.22445	0.40	0.0003%	0.40
1-PM	Organic Rinse (B½)	207.2	AA059	Tare 1	2.23984	2.24047	--	--	--
				Tare 2	2.23970	2.24053	--	--	--
				Tare 3	2.23971	2.24048	--	--	--
				Average	2.23975	2.24049	0.74	0.0003%	0.74
2-PM	Organic Rinse (B½)	179.5	AA060	Tare 1	2.20013	2.20074	--	--	--
				Tare 2	2.20000	2.20090	--	--	--
				Tare 3	2.19996	2.20087	--	--	--
				Average	2.20003	2.20084	0.81	0.0003%	0.81
3-PM	Organic Rinse (B½)	201.8	AA062	Tare 1	2.20092	2.20185	--	--	--
				Tare 2	2.20075	2.20184	--	--	--
				Tare 3	2.20080	2.20185	--	--	--
				Average	2.20082	2.20185	1.02	0.0003%	1.02
FRB-PM	Aqueous Water (B½)	95.3	AA065	Tare 1	2.11958	2.12017	--	--	--
				Tare 2	2.11967	2.12009	--	--	--
				Tare 3	2.11958	2.12009	--	--	--
				Average	2.11961	2.12012	0.51	0.0005%	0.51
1-PM	Aqueous Water (B½)	270.7	V018	Tare 1	81.1937	81.1947	--	--	--
				Tare 2	81.1936	81.1943	--	--	--
				Tare 3	81.1937	81.1942	--	--	--
				Average	81.1937	81.1944	0.73	0.0005%	0.73
2-PM	Aqueous Water (B½)	241.5	192A	Tare 1	68.2443	68.2465	--	--	--
				Tare 2	68.2438	68.2468	--	--	--
				Tare 3	68.2442	68.2463	--	--	--
				Average	68.2441	68.2465	2.43	0.0005%	2.43
3-PM	Aqueous Water (B½)	261.6	2073	Tare 1	68.8260	68.8263	--	--	--
				Tare 2	68.8255	68.8264	--	--	--
				Tare 3	68.8260	68.8266	--	--	--
				Average	68.8258	68.8264	0.60	0.0005%	0.60



LABORATORY NARRATIVE

EPA METHOD 5/202

Client: Bloom Energy Sunnyvale

Project: PROJ - 012216

Custody

Three sets of samples were received on January 14th, 2022. Each set consisted of a filter, probe/nozzle rinse, condensable particulate matter filter, impinger water and organic rinse. A set of field blanks, two sets of proof blanks, and a set of reagent blanks were also received. According to the chain-of-custody, these samples collected on January 11th, 2022. Sample bottles were marked with no evident sample loss.

Analysis

Samples were analyzed for particulate matter using the analytical procedures in EPA Methods 5 (Determination of Particulate Matter Emissions from Stationary Sources) and 202 (Determination of Condensable Particulate Matter Emissions from Stationary Sources). Samples were analyzed from January 17th, 2022 to January 20th, 2022 after desiccating for at least 24 hours. The results were blank corrected according to the test methods.

Front-Half Analysis

The filters were white in color. The probe/nozzle rinses appeared as white residues with tiny black particulate.

Back-Half Analysis

The organic fractions appeared as white residues with tiny black particulates. The aqueous fractions appeared as white residues upon evaporation except for 2-PM which had a lot of residues with tiny particulates.

QC Notes

Prior to analysis, the accuracy of the balance was checked using 500 mg, 2 g, and 100 g ASTM E617-97 Class 1 Stainless Steel weights. Results below detection limits are reported as the detection limit.



SAMPLE ACCEPTANCE CHECKLIST

Section 1

Client: Bloom ~~techo~~ Energy Sunnyvale Project: PROJ-012216 Test Method: EPA 5/202
 Date Received: 1/14/22 Sampler's Name Present: ☒ Yes ☐ No

Section 2

Sample Temperature (°C): Ambient
 Testing: ☐ Compliance ☐ RATA ☐ Engineering ☐ NA

Section 3

	Yes	No	NA
Was a COC included with the samples?	✓		
Are sample IDs present on the COC?	✓		
Are sampling dates present on the COC?	✓		
Is a relinquished signature present?	✓		
Are the test methods required clearly indicated on the COC?	✓		
Were the samples kept cold during transport?			✓
Were the samples placed under refrigeration for storage?			✓
Are the level of liquid marked on the sample bottle?	✓		
If the sample bottles are marked, was there in visible loss of sample?		✓	
Are the caps/seals intact?	✓		
Did all the bottle labels agree with the COC? (Sample IDs, content)	✓		
Did the samples labels include the project number?	✓		
Did the samples labels include the collection date?	✓		
Were the samples collected in the correct containers for the required tests.	✓		
Are the containers label with the correct preservatives?	✓		
Was a sufficient amount of sample submitted for the requested tests?	✓		

Section 4 Explanations/Comments

Section 5

For discrepancies, how was the Project Manager notified? ☐ Verbal PM Initials: _____ Date: _____
☐ Email (email sent to/on): _____ / _____
 Project Manager's response:

Completed By: Victor Garcia

Date: 1/14/22



CHAIN OF CUSTODY

Antioch Location

2825 Verne Roberts Circle
Antioch, CA 94509
Phone (925) 680-4300 | Fax (925) 680-4416

Lab info:

2825 Verne Roberts Circle
Antioch CA 94509

Client / Project: <i>MP1 1/17/22</i> Bloom Kechiocke <i>ENERGY SUNNYVALE</i>	Project / Sample Location: Kechiocke <i>MP1 1/17/22 YUMA ENERGY SERVER</i>	Test / Analytical Method: EPA 5/202
Project No.: 005AS-012216	Purchase Order No:	Special Analysis / Reporting Instructions: Hold reagent blanks and train proof blanks
Send Analytical Report To: Antioch QA/QC: AntiochQA-QC@montrose-env.com F. Schall		

Run / Sample No.	Date	Time	Containers	Sample Fraction	Reagent	Lab / Sample ID No.
1-PM	1/11/22		1	FPM Container 1 - filter	--	
"	1/11/22		1	FPM Container 2 - filterable PM rinse	acetone	
"	1/11/22		1	CPM Cont. 1 - aqueous liquid impinger contents	water	
"	1/11/22		1	CPM Container 2 - organic rinses	acetone & hexane	
"	1/11/22		1	CPM Container 3 - CPM filter	--	
2-PM	1/11/22		5	Same as Run 1	"	
3-PM	1/11/22		5	Same as Run 1	"	
FRB-PM	1/11/22		5	Field Recovery Blank - FPM C1, CPM C1-C3	"	
RB-PM-A	1/11/22		1	CPM Container 6 - acetone reagent blank	acetone	
RB-PM-B	1/11/22		1	CPM Container 7 - water reagent blank	water	
RB-PM-C	1/11/22		1	CPM Container 8 - hexane reagent blank	hexane	
TPB-PM 1,2,3	1/11/22		3	CPM Cont. 9 - train proof blank, inorganic rinses	water	
TPB-PM 1,2,3	1/11/22		3	CPM Cont. 10 - train proof blank, organic rinses	acetone & hexane	
Total Containers			29			

Relinquished by Finn	Date 1/14/2022	Time 1000	Received by <i>Victor Garcia</i>	Date 1/14/22	Time 1000	Temp.
Relinquished by	Date	Time	Received by	Date	Time	Temp.
Relinquished by	Date	Time	Received by	Date	Time	Temp.

Key: FPM = Filterable Particulate Matter, CPM = Condensable Particulate Matter, RB = Reagent Blank, FRB = Field Recovery Blank, TPB = Train Proof Blank

COC 202-1 set

Bloom Energy
2022 Engineering Source Test Report

Appendix C.2

Particulate Matter Analyses – Background



February 16, 2022

Steven D. Kohl
Desert Research Institute
2215 Raggio Parkway
Reno, NV 89512

Patrick Switzer
Montrose Air Quality Services, LLC
2825 Verne Roberts Circle
Antioch, CA 94509

Dear Mr. Switzer,

Enclosed please find gravimetric analysis results for the batch of Teflon filters that we provided for your particulate sampling project. Initial and final weights are shown in Table 1, tare and calibration check weights are in Table 2. All filter preparation and weighing were done at the Desert Research Institute's Environmental Analysis Facility (EAF).

DRI's EAF has been accredited annually for analysis of TSP, PM₁₀, and PM_{2.5} by gravimetry by the Texas Commission on Environmental Quality (TCEQ) under the National Environmental Laboratory Accreditation Program (NELAP) since 2007. As part of that accreditation process, we are audited roughly every 3 years. In addition, because we are a laboratory that performs analyses under EPA's Chemical Speciation Network, we have participated since 2005 in a program overseen by EPA's National Air and Radiation Environmental Laboratory (NAREL). This involves annual Performance Evaluation (PE) samples and laboratory inter-comparisons, including PM_{2.5} gravimetry. It also includes Technical Systems Audits (TSAs) roughly every 3 years.

For PM_{2.5} gravimetry we basically follow the procedures outlined in the following documents:

40 CFR Part 50, Appendix L - http://www.ecfr.gov/cgi-bin/text-idx?SID=4399bb569e1083e1f1cade9437f61bf6&node=ap40.2.50_118.l&rgn=div9

Section 2.12 of EPA's QA Handbook (11/98) -
<http://www.epa.gov/ttn/amtic/files/ambient/pm25/qa/m212covd.pdf>

EPA's QA Handbook – Vol. II (5/13) -
<http://www.epa.gov/ttn/amtic/files/ambient/pm25/qa/QA-Handbook-Vol-II.pdf>

In addition, some relevant SOPs and other information may be found at:

EPA CSN PE and Audit Results - <http://www.epa.gov/ttn/amtic/pmspec.html>

EPA PEP Program - <http://www.epa.gov/ttn/amtic/files/ambient/pm25/qa/peplsop.pdf>

NAREL - http://www.epa.gov/narel/sops/sop_pm2.5_mass.pdf

CARB - http://www.arb.ca.gov/aaqm/sop/mld055_fin.pdf

Sincerely,

Steven D. Kohl

Steven D. Kohl
Associate Research Scientist
Desert Research Institute

Table 1

TID	MSGF	MSGC	MSGU	Initial Weight	Final Weight	Initial Date	Final Date
MEGPT1064		36.000	3.152	186.704	186.740	2/24/21 11:02	2/3/22 8:40
MEGPT1065		44.000	3.152	152.725	152.769	2/24/21 11:03	2/3/22 8:41
MEGPT1067		-5.000	3.152	191.059	191.054	2/24/21 11:05	2/3/22 8:42
MEGPT1083		45.000	3.152	172.159	172.204	3/30/21 12:14	2/3/22 8:43
MEGPT1065	ri			152.730		2/24/21 11:36	
MEGPT1067	ri			191.056		2/24/21 11:38	
MEGPT1064	ri,rf	40.000	3.152	186.702	186.742	2/24/21 11:35	2/3/22 8:53
MEGPT1083	ri,rf	47.000	3.152	172.158	172.205	3/30/21 12:22	2/3/22 8:54
TID	Teflon filter ID						
MSGF	Gravimetry analysis flag (ri = replicate initial weight, rf = replicate final weight)						
MSGC	Mass concentration ($\mu\text{g}/\text{filter}$)						
MSGU	Mass concentration uncertainty ($\mu\text{g}/\text{filter}$)						
Initial Weight	Filter initial mass in milligrams						
Final Weight	Filter final mass in milligrams						
Initial Date	Initial weighing date						
Final Date	Final weighing date						

Table 2

DRIFiltID	WtDatTim	Weight			
TARECHECK	2/24/21 8:55	0			
CALIBCHECK	2/24/21 8:55	50.003		50 mg weight = 50.005 +/- 0.003	
CALIBCHECK	2/24/21 8:56	100.002		100 mg weight = 100.003 +/- 0.003	
CALIBCHECK	2/24/21 8:57	200.001		200 mg weight = 200.000 +/- 0.003	
CALIBCHECK	2/24/21 8:57	499.996		500 mg weight = 499.995 +/- 0.005	
TARECHECK	2/24/21 11:19	0			
CALIBCHECK	2/24/21 11:20	199.998			
CALIBCHECK	2/24/21 11:21	499.991			
TARECHECK	2/24/21 12:14	0			
CALIBCHECK	2/24/21 12:14	199.998			
CALIBCHECK	2/24/21 12:15	499.993			
TARECHECK	3/30/21 10:19	0			
CALIBCHECK	3/30/21 10:20	50.003			
CALIBCHECK	3/30/21 10:21	100.002			
CALIBCHECK	3/30/21 10:22	199.999			
CALIBCHECK	3/30/21 10:22	499.994			
TARECHECK	3/30/21 12:36	0			
CALIBCHECK	3/30/21 12:37	199.999			
CALIBCHECK	3/30/21 12:37	499.992			
TARECHECK	2/3/22 8:08	0		50 mg weight = 50.002 +/- 0.003	
CALIBCHECK	2/3/22 8:09	199.998		100 mg weight = 100.001 +/- 0.003	
CALIBCHECK	2/3/22 8:09	500.008		200 mg weight = 199.995 +/- 0.003	
TARECHECK	2/3/22 8:44	0		500 mg weight = 500.005 +/- 0.005	
CALIBCHECK	2/3/22 8:45	199.996			
CALIBCHECK	2/3/22 8:45	500.007			
TARECHECK	2/3/22 9:06	0			
CALIBCHECK	2/3/22 9:07	199.996			
CALIBCHECK	2/3/22 9:07	500.009			



Batch 53

2825 Verne Roberts Circle
Antioch, CA 94509
Phone (925) 680-4300 | Fax (925) 680-4416

Desert Research Institute
2215 Raggio Parkway
Reno NV 89501

Client / Project: Bloom Keehlocko	Project / Sample Location: YUMA	Test / Analytical Method: EPA of tm 37
Project No.: 005AS-012216	Purchase Order No:	Special Analysis / Reporting Instructions:
Send Analytical Report To: Antioch QA/QC: AntiochQA-QC@montrose-env.com F. Schall	Sampler or PM Signature: 	

Run / Sample No.	Date	Time	Containers	Sample Fraction	Reagent	Lab / Sample ID No.
1-PM-yuma ambient	1/11/22	2010	1	FPM Container 1 - filter	--	
2-PM-yuma ambient	1/11/22	2010	1	FPM Container 1 - filter	--	
3-PM-yuma ambient	1/11/22	2010	1	FPM Container 1 - filter	--	
Total Containers			3			

Relinquished by F. S. Hall	Date 1/31/22	Time 1030	Received by Esha	Date 1/31/22	Time 1035	Temp.
Relinquished by Esha to Fedex	Date 1/31/22	Time 1051	Received by LR	Date 2/1/22	Time 950	Temp. 1°C
Relinquished by	Date	Time	Received by	Date	Time	Temp.

Key: FPM = Filterable Particulate Matter, CPM = Condensable Particulate Matter, RB = Reagent Blank, FRB = Field Recovery Blank, TPB = Train Proof Blank

COC ambient PM

DocuSign Envelope ID: 7E118E9F-03A1-488E-8886-ABEF54DDF511

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APPENDIX D

QUALITY ASSURANCE/QUALITY CONTROL

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Appendix D.1

Units and Abbreviations



UNITS AND ABBREVIATIONS

@ X% O ₂	corrected to X% oxygen (corrected for dilution air)
CC	absolute value of the confidence coefficient
d	absolute value of the mean differences
°C	degrees Celsius (centigrade)
°F	degrees Fahrenheit
°R	degrees Rankine
" H ₂ O	inches of water column
13.6	specific gravity of mercury
ΔH	pressure drop across orifice meter, inches H ₂ O
ΔP	velocity head of stack gas, inches H ₂ O
θ	total sampling time, minutes
μg	microgram
ρ _a	density of acetone, mg/ml
ρ _w	density of water, 0.9982 g/ml or 0.002201 lb/ml
acfm	actual cubic feet of gas per minute at stack conditions
A _n	cross-sectional area of nozzle, ft ²
A _s	cross-sectional area of stack, square feet (ft ²)
Btu	British thermal unit
B _{ws}	proportion by volume of water vapor in gas stream
C _a	particulate matter concentration in stack gas, gr/acf
C _{Avg}	average unadjusted gas concentration, ppmv
C _{Dir}	measured concentration of calibration gas, ppmv
cf or ft ³	cubic feet
cfm	cubic feet per minute
C _{Gas}	average gas concentration adjusted for bias, ppmv
C _M	average of initial and final system bias check responses from upscale calibration gas, ppmv
cm or m ³	cubic meters
C _{MA}	actual concentration of the upscale calibration gas, ppmv
C _O	average of initial and final system bias check responses from low-level calibration gas, ppmv
C _p	pitot tube coefficient
C _s	particulate matter concentration in stack gas, gr/dscf
CS	calibration span, % or ppmv
C _S	measured concentration of calibration gas, ppmv
C _V	manufactured certified concentration of calibration gas, ppmv
D	drift assessment, % of span
dcf	dry cubic feet
dcm	dry cubic meters
D _n	diameter of nozzle, inches
D _s	diameter of stack, inches
dscf	dry standard cubic feet
dscfm	dry standard cubic feet per minute
dscm	dry standard cubic meters
F _d	F-factor, dscf/MMBtu of heat input
fpm	feet per minute
fps	feet per second
ft	feet
ft ²	square feet
g	gram
gal	gallons
gr	grains (7000 grains per pound)



UNITS AND ABBREVIATIONS

gr/dscf	grains per dry standard cubic feet
hr	hour
I	percent of isokinetic sampling
in	inch
k	kilo or thousand (metric units, multiply by 10^3)
K	kelvin (temperature)
K_3	conversion factor 0.0154 gr/mg
K_4	conversion factor 0.002668 ((in. Hg)(ft ³))/((ml)(°R))
kg	kilogram
K_p	pitot tube constant (85.49 ft/sec)
kwscfh	thousand wet standard cubic feet per hour
l	liters
lb/hr	pounds per hour
lb/MMBtu	pounds per million Btu
lpm	liters per minute
m	meter or milli
M	thousand (English units) or mega (million, metric units)
m ³	cubic meters
m_a	mass of residue of acetone after evaporation, mg
M_d	molecular weight of stack gas; dry basis, lb/lb-mole
meq	milliequivalent
mg	milligram
Mg	megagram (10^6 grams)
min	minute
ml or mL	milliliter
mm	millimeter
MM	million (English units)
MMBtu/hr	million Btu per hour
m_n	total amount of particulate matter collected, mg
mol	mole
mol. wt. or MW	molecular weight
M_s	molecular weight of stack gas; wet basis, lb/lb-mole
MW	molecular weight or megawatt
n	number of data points
ng	nanogram
nm	nanometer
P_{bar}	barometric pressure, inches Hg
pg	picogram
P_g	stack static pressure, inches H ₂ O
P_m	barometric pressure of dry gas meter, inches Hg
ppb	parts per billion
ppbv	parts per billion, by volume
ppbvd	parts per billion by volume, dry basis
ppm	parts per million
ppmv	parts per million, by volume
ppmvd	parts per million by volume, dry basis
P_s	absolute stack gas pressure, inches Hg
psi	pounds per square inch
psia	pounds per square inch absolute
psig	pounds per square inch gauge
P_{std}	standard absolute pressure, 29.92 inches Hg
Q_a	volumetric flow rate, actual conditions, acfm



UNITS AND ABBREVIATIONS

Q_s	volumetric flow rate, standard conditions, scfm
Q_{std}	volumetric flow rate, dry standard conditions, dscfm
R	ideal gas constant 21.85 ((in. Hg) (ft ³))/((°R) (lbmole))
SB_{final}	post-run system bias check, % of span
SB_i	pre-run system bias check, % of span
scf	standard cubic feet
scfh	standard cubic feet per hour
scfm	standard cubic feet per minute
scm	standard cubic meters
scmh	standard cubic meters per hour
sec	second
sf, sq. ft., or ft ²	square feet
std	standard
t	metric ton (1000 kg)
$T_{0.975}$	t-value
T_a	absolute average ambient temperature, °R (+459.67 for English)
T_m	absolute average dry gas meter temperature, °R (+459.67 for English)
ton or t	ton = 2000 pounds
tph or tons/hr	tons per hour
tpy or tons/yr	tons per year
T_s	absolute average stack gas meter temperature, °R (+459.67 for English)
T_{std}	absolute temperature at standard conditions
V	volt
V_a	volume of acetone blank, ml
V_{aw}	volume of acetone used in wash, ml
V_{lc}	total volume H ₂ O collected in impingers and silica gel, grams
V_m	volume of gas sampled through dry gas meter, ft ³
$V_{m(std)}$	volume of gas measured by the dry gas meter, corrected to standard conditions, dscf
V_{ma}	stack gas volume sampled, acf
V_n	volume collected at stack conditions through nozzle, acf
V_s	average stack gas velocity, feet per second
$V_{wc(std)}$	volume of water vapor condensed, corrected to standard conditions, scf
$V_{wi(std)}$	volume of water vapor in gas sampled from impingers, scf
$V_{wsg(std)}$	volume of water vapor in gas sampled from silica gel, scf
W	watt
W_a	weight of residue in acetone wash, mg
W_{imp}	total weight of impingers, grams
W_{sg}	total weight of silica gel, grams
Y	dry gas meter calibration factor, dimensionless



ACRONYMS

AAS	atomic absorption spectroscopy
ACDP	air contaminant discharge permit
ACE	analyzer calibration error, percent of span
AD	absolute difference
ADL	above detection limit
AETB	Air Emissions Testing Body
AS	applicable standard (emission limit)
ASTM	American Society For Testing And Materials
BACT	best achievable control technology
BDL	below detection limit
BHP	brake horsepower
BIF	boiler and industrial furnace
BLS	black liquor solids
CC	confidence coefficient
CD	calibration drift
CE	calibration error
CEM	continuous emissions monitor
CEMS	continuous emissions monitoring system
CERMS	continuous emissions rate monitoring system
CET	calibration error test
CFR	Code of Federal Regulations
CGA	cylinder gas audit
CHNOS	elemental analysis for determination of C, H, N, O, and S content in fuels
CNCG	concentrated non-condensable gas
CO	catalytic oxidizer
COC	chain of custody
COMS	continuous opacity monitoring system
CPM	condensible particulate matter
CPMS	continuous parameter monitoring system
CT	combustion turbine
CTM	conditional test method
CTO	catalytic thermal oxidizer
CVAAS	cold vapor atomic absorption spectroscopy
D _e	equivalent diameter
DE	destruction efficiency
Dioxins	polychlorinated dibenzo-p-dioxins (pcdd's)
DLL	detection level limited
DNCG	dilute non-condensable gas
ECD	electron capture detector
EIT	Engineer In Training
ELCD	electroconductivity detector (hall detector)
EMPC	estimated maximum possible concentration
EPA	US Environmental Protection Agency
EPRI	Electric Power Research Institute
ES	emission standard (applicable limit)
ESP	electrostatic precipitator
EU	emission unit
FCCU	fluid catalytic cracking unit
FGD	flue gas desulfurization
FI	flame ionization
FIA	flame ionization analyzer
FID	flame ionization detector
FPD	flame photometric detector
FPM	filterable particulate matter



ACRONYMS

FTIR	Fourier-transform infrared spectroscopy
FTPb	field train proof blank
FTRb	field train recovery blank
Furans	polychlorinated dibenzofurans (pcdf's)
GC	gas chromatography
GC/MS	gas chromatography/mass spectroscopy
GFAAS	graphite furnace atomic absorption spectroscopy
GFC	gas filter correlation
GHG	greenhouse gas
HAP	hazardous air pollutant
HC	hydrocarbons
HHV	higher heating value
HPLC	high performance liquid chromatography
HRGC/HRMS	high-resolution gas chromatography/high-resolution mass spectroscopy
HRSG	heat recovery steam generator
IC	ion chromatography
ICAP	inductively-coupled argon plasmography
ICPCR	ion chromatography with a post-column reactor
ICP-MS	inductively coupled plasma-mass spectroscopy
IR	infrared radiation
ISO	International Standards Organization
kW	kilowatts
LFG	landfill gas
LHV	lower heating value
LPG	liquified petroleum gas
MACT	maximum achievable control technology
MDI	methylene diphenyl diisocyanate
MDL	method detection limit
MNOC	maximum normal operating conditions
MRL	method reporting limit
MS	mass spectrometry
NA	not applicable or not available
NCASI	National Council For Air And Steam Improvement
NCG	non-condensable gases
ND	not detected
NDIR	non-dispersive infrared
NESHAP	National Emissions Standards For Hazardous Air Pollutants
NG	natural gas
NIOSH	National Institute For Occupational Safety And Health
NIST	National Institute Of Standards And Technology
NMC	non-methane cutter
NMOC	non-methane organic compounds
NMVOC	non-methane volatile organic compounds
NPD	nitrogen phosphorus detector
NSPS	New Source Performance Standards
OSHA	Occupational Safety And Health Administration
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyl compounds
PCWP	plywood and composite wood products
PE	Professional Engineer
PFAS	per- and polyfluoroalkyl substances (PFAS)
PI	photoionization
PID	photoionization detector
PM	particulate matter



ACRONYMS

PM ₁₀	particulate matter less than 10 microns in aerodynamic diameter
PM _{2.5}	particulate matter less than 2.5 microns in aerodynamic diameter
POM	polycyclic organic matter
PS	performance specification
PSD	particle size distribution
PSEL	plant site emission limits
PST	performance specification test
PTE	permanent total enclosure
PTM	performance test method
QA/QC	quality assurance and quality control
QI	Qualified Individual
QSTI	Qualified Source Testing Individual
RA	relative accuracy
RAA	relative accuracy audit
RACT	reasonably available control technology
RATA	relative accuracy test audit
RCTO	rotary concentrator thermal oxidizer
RICE	stationary reciprocating internal combustion engine
RM	reference method
RTO	regenerative thermal oxidizer
SAM	sulfuric acid mist
SCD	sulfur chemiluminescent detector
SCR	selective catalytic reduction system
SD	standard deviation
Semi-VOST	semivolatile organic compounds sample train
SRM	standard reference material
TAP	toxic air pollutant
TBD	to be determined
TCA	thermal conductivity analyzer
TCD	thermal conductivity detector
TGNENMOC	total gaseous non-ethane non-methane organic compounds
TGNMOC	total gaseous non-methane organic compounds
TGOC	total gaseous organic compounds
THC	total hydrocarbons
TIC	tentatively identified compound
TO	thermal oxidizer
TO	toxic organic (as in EPA Method TO-15)
TPM	total particulate matter
TSP	total suspended particulate matter
TTE	temporary total enclosure
ULSD	ultra-low sulfur diesel
UV	ultraviolet radiation range
VE	visible emissions
VOC	volatile organic compounds
VOST	volatile organic sample train
WC	water column
WWTP	waste water treatment plant



CHEMICAL NOMENCLATURE

Ag	silver	Se	selenium
As	arsenic	SO ₂	sulfur dioxide
Ba	barium	SO ₃	sulfur trioxide
Be	beryllium	SO _x	sulfur oxides
C	carbon	TCDD	tetrachlorodibenzodioxin
Cd	cadmium	TCDF	tetrachlorodibenzofuran
CdS	cadmium sulfide	TGOC	total gaseous organic concentration
CH ₂ O	formaldehyde	THC	total hydrocarbons
CH ₃ CHO	acetaldehyde	TI	thallium
CH ₃ OH	methanol	TRS	total reduced sulfur compounds
CH ₄	methane	Zn	zinc
C ₂ H ₄ O	ethylene oxide		
C ₂ H ₆	ethane		
C ₃ H ₄ O	acrolein		
C ₃ H ₆ O	propionaldehyde		
C ₃ H ₈	propane		
C ₆ H ₅ OH	phenol		
Cl ₂	chlorine		
ClO ₂	chlorine dioxide		
CO	carbon monoxide		
Co	cobalt		
CO ₂	carbon dioxide		
Cr	chromium		
Cu	copper		
EtO	ethylene oxide		
EtOH	ethyl alcohol (ethanol)		
H ₂	hydrogen		
H ₂ O	water		
H ₂ O ₂	hydrogen peroxide		
H ₂ S	hydrogen sulfide		
H ₂ SO ₄	sulfuric acid		
HCl	hydrogen chloride		
Hg	mercury		
IPA	isopropyl alcohol		
MDI	methylene diphenyl diisocyanate		
MeCl ₂	methylene chloride		
MEK	methyl ethyl ketone		
MeOH	methanol		
Mn	manganese		
N ₂	nitrogen		
NH ₃	ammonia		
Ni	nickel		
NO	nitric oxide		
NO ₂	nitrogen dioxide		
NO _x	nitrogen oxides		
O ₂	oxygen		
P	phosphorus		
Pb	lead		
PCDD	polychlorinated dibenzo-p-dioxins		
PCDF	polychlorinated dibenzofurans		
Sb	antimony		

Bloom Energy
2022 Engineering Source Test Report

Appendix D.2

Manual Test Method QA/QC Data



EPA Method 5
Meter Box Calibration by Calibrated Critical Orifice,
Leak Check, and Thermocouple Calibration Check
English Meter Box Units, English K' Factor

Meter box ID:	CB 23
Meter ID (if applicable):	CB 23
Orifice set ID:	Antioch
Calibrated by:	RM
Expires:	4/7/22

Date:	10/7/21
Location:	Antioch
No. of orifices used (min. 3)	5
Barometric pressure (in. Hg):	29.99 in. Hg
Theoretical critical vacuum	14.15 in. Hg

Yd:	0.985
ΔH@:	1.853

Meter Box Orifice Calibration

IMPORTANT For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above
 IMPORTANT The Critical Orifice Coefficient, K', must be entered in English units, (ft³/3" (deg R)^{0.5}/((in. Hg)^{0.5}/(min)).

ΔH (in. H ₂ O)	Time (min)	Volume		Net (cu ft)	Initial Temps.		Final Temps.		Orifice Serial# (number)	K' Orifice Coefficient (see above)	Vacuum (in. Hg)	— Ambient Temperature —		
		Initial (cu ft)	Final (cu ft)		Inlet (deg F)	Outlet (deg F)	Inlet (deg F)	Outlet (deg F)				Initial (deg F)	Final (deg F)	Average (deg F)
0.33	17.00	795.822	801.151	5.329	73.0	73.0	73.0	73.0	RG-40	0.2355	16.0	71.0	71.0	71.0
0.68	12.00	801.151	806.691	5.540	73.0	73.0	74.0	74.0	RG-48	0.3481	16.0	71.0	71.0	71.0
1.10	12.00	776.705	783.588	6.883	71.0	71.0	71.0	71.0	RG-55	0.4320	16.0	71.0	71.0	71.0
1.90	9.00	783.568	790.670	7.102	71.0	71.0	72.0	72.0	RG-63	0.5959	16.0	71.0	71.0	71.0
3.20	5.00	790.670	795.822	5.152	72.0	72.0	73.0	73.0	RG-73	0.7849	16.0	71.0	71.0	71.0

— SAMPLE RATE —
 INDICATED VS. ACTUAL

ΔH (in. H ₂ O)	Sample Rate (scfm)
0.33	0.306
0.68	0.450
1.10	0.862
1.90	0.778
3.20	1.022

— DRY GAS METER —

VOLUME CORRECTED
Vm(std) (cu ft)
5.294
5.503
6.856
7.102
5.169

— ORIFICE —

VOLUME CORRECTED	VOLUME NOMINAL
Vor(std) (cu ft)	Vcr (cu ft)
5.210	5.290
5.405	5.425
6.747	6.772
6.980	7.006
5.108	5.127

— DRY GAS METER —

CALIBRATION FACTOR	
Yd	
Value (number)	Variation (number)
0.9843	0.000
0.9823	-0.002
0.9841	-0.001
0.983	-0.002
0.990	0.005

— ORIFICE —

CALIBRATION FACTOR $\Delta H@$	
Value (in H ₂ O)	Variation (in H ₂ O)
1.962	0.109
1.870	0.017
1.951	0.098
1.769	-0.084
1.714	-0.138

For Calibration Factor Yd, the ratio of the reading of the calibration meter to the dry gas meter,
 acceptable tolerance of individual values from the average is ± 0.02 .

For Orifice Calibration Factor ΔH@, the orifice differential pressure in inches of H₂O that equates to 0.75 cfm of air
 at 68 F and 29.92 inches of Hg, acceptable tolerance of individual values from the average is ± 0.2 .

QA Criteria:

Average Yd	0.9847
Average ΔH@	1.8534
Variation of Yd's	PASS
Variation of ΔH@	PASS
Vacuum Criteria	PASS

Meter Box Pressure Leak Check

Test Pressure, (in. H ₂ O):	6	Should be 5-7 in. H ₂ O
Leak Rate, (in. H ₂ O/min):	0	Must be zero (manometer level stable for 1 minute)

Meter Box Vacuum Leak Check

Test Vacuum, (in. Hg):	25	Coarse adjust valve fully open, fine adjust fully closed, sample inlet plugged
Leak Rate, (cfm):	0	Must be zero (meter dial stable for 1 minute)

Meter Box Thermocouple Readout Calibration Check

Input Temperature	Allowable Temp. Dev.*	Low	High
30	7	23	37
70	8	62	78
120	9	111	129
250	11	239	261
350	12	338	362
500	14	486	514
700	17	683	717
900	20	880	920

Stack	Probe	Filter	Exit	Aux.
28	28	28	29	28
67	67	68	67	68
118	118	119	118	118
250	250	251		
349	349	350		
497				
700				
901				

Thermocouple simulator	
Make:	Omega
Model:	CL125
Serial Number:	16200736
Cal Date:	12/18/2020

* Reading values must be within 1.5% of reference thermometer values (based on absolute temperature scale) for calibration to be acceptable.

Performed by: Name: Raul Moreno

Signature: *Raul Moreno* Date: 10/7/21

Approved by:

Name: *Nikhil Patel*

Signature: *Nikhil Patel* Date: 10/8/21



EPA Method 5

Meter Box Calibration by Calibrated Critical Orifice, Leak Check, and Thermocouple Calibration Check

English Meter Box Units, English K' Factor

Meter box ID:	CB 10
Meter ID (if applicable):	CB 10
Orifice set ID:	Antioch
Calibrated by:	RM
Expires:	4/7/22

Date:	10/7/21
Location:	Antioch
No. of orifices used (min. 3)	5
Barometric pressure (in. Hg):	29.99 in. Hg
Theoretical critical vacuum	14.15 in. Hg

Yd:	1.004
$\Delta H@$:	1.727

Meter Box Orifice Calibration

IMPORTANT For valid test results, the Actual Vacuum should be 1 to 2 in. Hg greater than the Theoretical Critical Vacuum shown above
IMPORTANT The Critical Orifice Coefficient, K', must be entered in English units, $(ft)^3/(deg F)(min)$.

ΔH (in H ₂ O)	Time (min)	Volume			Initial Temps.		Final Temps.		Orifice Serial# (number)	K' Orifice Coefficient (see above)	— Ambient Temperature —			
		Initial (cu ft)	Final (cu ft)	Net (cu ft)	Inlet (deg F)	Outlet (deg F)	Inlet (deg F)	Outlet (deg F)			Vacuum (in Hg)	Initial (deg F)	Final (deg F)	Average (deg F)
0.32	17.00	542.420	547.582	5.162	66.0	66.0	67.0	67.0	RG-40	0.2355	16.0	71.0	71.0	71.0
0.60	12.00	547.582	552.930	5.348	67.0	67.0	68.0	68.0	RG-48	0.3461	16.0	71.0	71.0	71.0
0.95	10.00	525.008	530.543	5.535	62.0	62.0	64.0	64.0	RG-55	0.4320	16.0	71.0	71.0	71.0
1.80	9.00	530.543	537.415	6.872	64.0	64.0	65.0	65.0	RG-63	0.5959	16.0	71.0	71.0	71.0
3.00	5.00	537.415	542.420	5.005	65.0	65.0	66.0	66.0	RG-73	0.7849	16.0	71.0	71.0	71.0

— SAMPLE RATE —
INDICATED VS. ACTUAL

ΔH (in H ₂ O)	Sample Rate (scfm)
0.32	0.306
0.60	0.450
0.95	0.562
1.80	0.776
3.00	1.022

— DRY GAS METER —
VOLUME
CORRECTED

Vm(std) (cu ft)
5.191
5.371
5.612
6.962
5.076

— ORIFICE —
VOLUME
CORRECTED

Vc(std) (cu ft)	Vc (cu ft)
5.210	5.230
5.405	5.425
5.622	5.643
6.980	7.006
5.108	5.127

— DRY GAS METER —
CALIBRATION FACTOR
Yd

Value (number)	Variation (number)
1.0038	0.000
1.0063	0.002
1.0019	-0.002
1.003	-0.002
1.006	0.002

— ORIFICE —
CALIBRATION FACTOR
 $\Delta H@$

Value (in H ₂ O)	Variation (in H ₂ O)
1.926	0.200
1.669	-0.058
1.711	-0.016
1.699	-0.028
1.629	-0.098

For Calibration Factor Yd, the ratio of the reading of the calibration meter to the dry gas meter, acceptable tolerance of individual values from the average is ± 0.02 .

For Orifice Calibration Factor $\Delta H@$, the orifice differential pressure in inches of H₂O that equates to 0.75 cfm of air at 68 F and 29.92 inches of Hg, acceptable tolerance of individual values from the average is ± 0.2 .

QA Criteria:	
Average Yd	1.0042
Average $\Delta H@$	1.7266
Variation of Yd's	PASS
Variation of $\Delta H@$	PASS
Vacuum Criteria	PASS

Meter Box Pressure Leak Check

Test Pressure, (in H ₂ O):	6	Should be 5-7 in. H ₂ O
Leak Rate, (in H ₂ O/min):	0	Must be zero (manometer level stable for 1 minute)

Meter Box Vacuum Leak Check

Test Vacuum, (in. Hg):	25	Coarse adjust valve fully open, fine adjust fully closed, sample inlet plugged
Leak Rate, (cfm):	0	Must be zero (meter dial stable for 1 minute)

Meter Box Thermocouple Readout Calibration Check

Input Temperature	Allowable Temp. Dev.*	Low	High
30	7	23	37
70	8	62	78
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250	11	239	261
350	12	338	362
500	14	486	514
700	17	683	717
900	20	880	920

Stack	Probe	Filter	Exit	Aux.
26	26	26	27	26
66	66	65	65	65
116	116	115	115	116
248	248	247		
347	347	347		
495				
698				
898				

Thermocouple simulator	
Make:	Omega
Model:	CL125
Serial Number	16200736
Cal Date:	12/18/2020

* Reading values must be within 1.5% of reference thermometer values (based on absolute temperature scale) for calibration to be acceptable.

Performed by: Name: Raul Moreno

Signature: *Raul Moreno* Date: 10/7/21

Approved by: Name: *Nikesh Patel*

Signature: *Nikesh Patel* Date: 10/8/21

RICE LAKE

Certificate of Weight Calibration

ISO/IEC 17025 & ANSI/NCSL-Z540-1-1994 ACCREDITED

Traceable Certificate Number: 3122859E
Contractor: MONTROSE AIR QUALITY SERVICES
 2825 VERNE ROBERTS CIR
 ANTIOCH, CA 94509-7902

Purchase Order Number: PO1058255
Client: MONTROSE AIR QUALITY SERVICES
 2825 VERNE ROBERTS CIR
 ANTIOCH, CA 94509-7902

Date Received: 05 Oct 2020
Date Calibrated: 05 Oct 2020
Recalibration Date: Oct 2021
NIST Certificate Number: 684/286541-15 & 684/284451-14

If there are two NIST numbers, one or both may apply

Calibrated By: VLS
Procedure: WI05-0023 Rev. K
Condition of Weights: Acceptable for Calibration
Description of Weights: 500 g Satin Finish Weight, ASTM Class 4, S/N: 1000131127, ID: W-6
Comments:

Key Notes

Finish ✱ Indicates the weight does not meet the finish requirements
Material ⊕ Indicates the weight does not meet the material requirements
New Wt ◇ Indicates new weight
Missing Wt ▲ Indicates replaced missing weight with new weight
Damaged Wt ✕ Indicates replaced damaged weight
Replaced OOT ★ Indicates replaced out of tolerance weight
OOT ⊗ Indicates correction plus or minus Uncertainty greater than or equal to MPE
Magnetic Wt ★★ Indicates replaced magnetic weight
Design ⊗ Indicates the weight does not meet the design or shape requirements
Repainted 🖌 Indicates the weight was repainted after As Found obtained
Other Ⓢ See comments above

Cleaning Levels

A Dusted with brush or cloth
B Spot cleaned with ethyl alcohol
C Full surface cleaned with ethyl alcohol
D Spot cleaned with non-alcohol solvent followed by ethyl alcohol
E Full surface cleaned with non-alcohol solvent followed by ethyl alcohol
F No cleaning performed

Material Abbreviations

AL	Aluminum	TA	Tantalum
SS	Stainless Steel	BR	Brass
CI	Cast Iron	PL	Platinum
IR	Iron	NS	Nickel Silver
MS	Mild Steel	OR	Other/Unknown

Check with your local state agency for certification of compliance on Legal-for-Trade items. The weight accuracy class is referenced in the Description of Weights. Unless otherwise noted, the weights calibrated meet the requirements of the accuracy class. Results relate only to weights calibrated. The Surface Finishes of weights are evaluated visually. Weights are screened for magnetism using work instruction WI05-0035 when they are new, when requested by the customer or when weights are suspected of not meeting specifications. Density if measured is measured using OIML R111-1 (2004) method A2. Conventional Mass is reported based on a reference density of 8.0 g/cm³. The Uncertainty of Measurement is included in the determination of Maximum Permissible Error (MPE) Pass/Fail Criteria. The specifications for Maximum Permissible Error (MPE) can be found in NIST Handbook 105-1 (2019), NIST Handbook 105-1 (1990), ASTM E617-18 or OIML R111-1 (2004), manufacturer specifications or customer specifications.

The Uncertainty assigned to the Conventional Mass values are the result of the root-sum-square of the type A and type B components, calculated in accordance with NIST SOP 29 and the Guide to the expression of uncertainty in measurement, with coverage factor ($k=2$), to express the expanded uncertainty with an approximate 95.45% confidence level. This report is not to be used to claim product certification, approval, or endorsement by NVLAP, NIST, A2LA, or any government agency. This document shall not be reproduced, except in full, without the written approval of Rice Lake Weighing Systems.

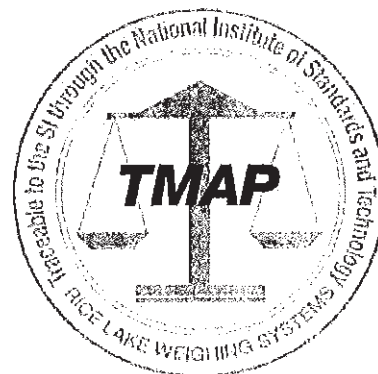
V. Shephardson
 Victoria Shephardson, Authorized Signatory

06 Oct 2020

Date:



Prepared By:
Rice Lake Weighing Systems • PN 179125 • 06/20
 1400 Willow Pass Court • Concord, CA 94520 • USA
 TEL: 800-672-1440 • FAX: 715-234-6967
 Definitions: <http://certs.ricelake.com/certs/DefinitionsV2.docx>
 Page 1 of 2 74 of 89



Certificate of Weight Calibration

ISO/IEC 17025 & ANSI/NCSL-Z540-1-1994 ACCREDITED

Traceable Certificate Number: 3122859E
 Client: MONTROSE AIR QUALITY SERVICES
 Date Calibrated: 05 Oct 2020

Temperature Range: 20.17 °C
 Pressure Range: 755.63 mmHg
 Relative Humidity Range: 49 %

As Left Data (As Found only shown when different than As Left)

Nominal Value	Unique ID	True Mass	True Mass Corr. (mg)	Conv. Mass	Conv. Mass Corr. (mg)	(k=2) Unc. (± mg)	MPE (± mg)	MPE Pass	Assumed Density (g/cm ³)	Assumed Material	Const. Type	Balance Used	Reference Standard Set Used	Air Density (mg/cm ³)	Clean Level
500 g		500.0036	3.6	500.0031	3.1	1.5	10	Y	7.95	SS	II	25	8	1.1918	A

Bloom Energy
2022 Engineering Source Test Report

Appendix D.3

Accreditation Information/Certifications



Gavin Newsom, Governor
Jared Blumenfeld, CalEPA Secretary
Mary D. Nichols, Chair

July 1, 2020

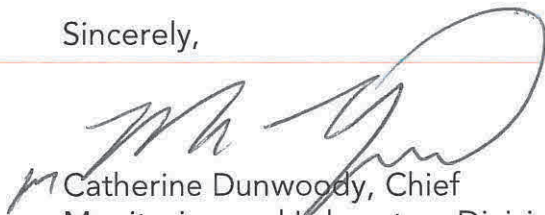
Mr. Matt McCune
Montrose Air Quality Services, LLC
1631 East Saint Andrew Place
Santa Ana, California 92705

Dear Mr. McCune:

I am pleased to inform you that the California Air Resources Board (CARB) has renewed, by means of enclosed Executive Order I-20-008, Montrose Air Quality Services, LLC to perform CARB Test Methods 1, 2, 3, 4, 5, 6, 8, 17, 20, and 100 (CO, CO₂, NO_x, O₂, SO₂, THC), Visible Emission Evaluation, and U.S. Environmental Protection Agency Test Methods 201A, 202, and 205. These approvals are valid through June 30, 2022, during which time additional audits of Montrose Air Quality Services, LLC's testing ability may be performed.

If you have questions or need further assistance, please contact Kathryn Gugeler at kathryn.gugeler@arb.ca.gov or Christopher Dilbeck at christopher.dilbeck@arb.ca.gov.

Sincerely,



Catherine Dunwoody, Chief
Monitoring and Laboratory Division

Enclosure

cc: Christopher Dilbeck, Manager
Testing and Certification Section

Kathryn Gugeler
Monitoring and Laboratory Division

**State of California
AIR RESOURCES BOARD**

EXECUTIVE ORDER I-20-008

**Approval of Independent Contractor Pursuant to
California Code of Regulations, title 17, section 91207**

Montrose Air Quality Services, LLC

WHEREAS, the California Air Resources Board (CARB), pursuant to California Health and Safety Code, section 41512, has established the procedures contained in California Code of Regulations, title 17, section 91200 and following, to allow the use of independent testers for compliance tests required by CARB;

WHEREAS, it has been determined that Montrose Air Quality Services, LLC meets the requirements of CARB for performing CARB Test Methods 1, 2, 3, 4, 5, 6, 8, 17, 20, and 100 (CO, CO₂, NO_x, O₂, SO₂, THC), Visible Emission Evaluation (VEE), and U.S. Environmental Protection Agency (U.S. EPA) Test Methods 201A, 202, and 205 pursuant to Cal. Code Regs., tit. 17, § 91200 and following, when the following conditions are met:

1. Montrose Air Quality Services, LLC permanently marks or engraves an identification number on the body of each of its pitot tubes in accordance with section 2.1 of CARB Test Method 2;
2. Montrose Air Quality Services, LLC calibrates its differential pressure gauges after each test series in accordance with section 2.2 of CARB Test Method 2, and establishes and maintains a log of the calibrations;
3. Montrose Air Quality Services, LLC calibrates its temperature gauges in accordance with section 4.3 of CARB Test Method 2, and establishes and maintains a log of the calibrations;
4. Montrose Air Quality Services, LLC calibrates its metering system in accordance with section 5.3 of CARB Test Method 5, and establishes and maintains a log of the calibrations;
5. Montrose Air Quality Services, LLC acquires and uses a 5-mL burette in accordance with section 2.3.3 of CARB Test Method 6 and section 4.2 of CARB Test Method 20;
6. Montrose Air Quality Services, LLC acquires and uses 300 to 500 mL glass beakers in accordance with Section 6.2.2(c) of U.S. EPA Test Method 202;
7. Montrose Air Quality Services, LLC uses desiccant in accordance with section 3.3.2 of CARB Test Methods 5 and 17, section 7.2.2 of U.S. EPA Test Method 201A, and section 7.2.4 of U.S. EPA Test Method 202;

-2-

8. The person performing VEE passed CARB Compliance Training Course #100: Fundamentals of Enforcement (FOE)/Visible Emissions Evaluation (Smoke School), or MM104: Visible Emissions Evaluation (Online) and MM105: Visible Emissions Evaluation (In Class), and is currently certified to conduct VEE. Any recertification for VEE, following the initial passage of CARB's FOE, must be from a certifying body recognized by CARB at the time VEE is performed; and

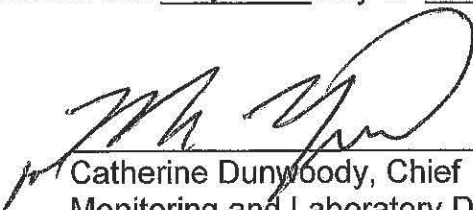
WHEREAS, CARB Executive Officer, pursuant to California Health and Safety Code Section 39516, issued Executive Order G-02-008, delegating to the Chief of CARB Monitoring and Laboratory Division (MLD) the authority to approve independent testers in accordance with Cal. Code Regs., tit. 17, § 91200 and following.

NOW, THEREFORE, I, Catherine Dunwoody, Chief of MLD, order that Montrose Air Quality Services, LLC is granted approval from the date of execution of this Executive Order through June 30, 2022, to perform the test methods identified above subject to compliance with Cal. Code Regs., tit. 17, § 91200 and following.

BE IT FURTHER ORDERED that during the approved period, the Executive Officer or his or her authorized representative may field audit one or more tests performed pursuant to this Executive Order for each test method identified above.

IT IS FURTHER ORDERED that Executive Order I-18-002 is superseded by this order.

Executed at Sacramento, California this 1st day of July 2020.


Catherine Dunwoody, Chief
Monitoring and Laboratory Division

State of California
California Air Resources Board
Approved Independent Contractor

Montrose Air Quality Services, LLC

This is to certify that the company listed above has been approved by the California Air Resources Board to conduct compliance testing pursuant to California Code of Regulations, title 17, section 91207, through June 30, 2022, for those test methods listed below:

CARB Source Test Methods:
1, 2, 3, 4, 5, 6, 8, 17, 20
100 (CO, CO₂, NO_x, O₂, SO₂, THC)


Catherine Dunwoody, Chief
Monitoring and Laboratory Division

State of California
California Air Resources Board
Approved Independent Contractor

Montrose Air Quality Services, LLC

This is to certify that the company listed above has been approved by the California Air Resources Board to conduct compliance testing pursuant to California Code of Regulations, title 17, section 91207, through June 30, 2022, for those test methods listed below:

U.S. EPA Source Test Methods 201A, 202 and 205
Visible Emissions Evaluation

Catherine Dunwoody, Chief
Monitoring and Laboratory Division

CERTIFICATE OF COMPLETION

Finnegan Schall

This document certifies that this individual has passed a comprehensive examination and is now a Qualified Individual (QI) as defined in Section 8.3 of ASTM D7036-04 for the following method(s):

Source Evaluation Society Group 1: *EPA Manual Gas Volume and Flow Measurements and Isokinetic Particulate Sampling Methods*

Certificate Number: 005-2019-1



Tate Strickler, Accreditation Director

DATE OF ISSUE: 3/30/19

DATE OF
EXPIRATION: 3/30/24

CERTIFICATE OF COMPLETION

Finnegan Schall

This document certifies that this individual has passed a comprehensive examination and is now a Qualified Individual (QI) as defined in Section 8.3 of ASTM D7036-04 for the following method(s):

Source Evaluation Society Group 3: *EPA Gaseous Pollutants Instrumental Sampling Methods*

Certificate Number: 005-2019-2



Tate Strickler, Accreditation Director

DATE OF ISSUE: 4/1/19

DATE OF
EXPIRATION: 4/1/24

Bloom Energy
2022 Engineering Source Test Report

Appendix D.4

Quality Assurance Program Summary and Equipment Calibration Schedule

QUALITY ASSURANCE PROGRAM SUMMARY AND CERTIFICATIONS

Montrose Air Quality Services, LLC (Montrose) ensures the quality and validity of its emission measurement and reporting procedures through a rigorous quality assurance (QA) program. The program is developed and administered by internal QA personnel and encompasses seven major areas:

1. Development and use of an internal QA manual
2. QA reviews of reports, laboratory work, and field testing
3. Equipment calibration and maintenance
4. Chain of custody
5. Continuous training
6. Knowledge of current test methods
7. Audit program

Each of these areas is discussed individually below.

Quality Assurance Manual. Montrose has prepared a QA Manual according to EPA guidelines and ASTM D-7036. The manual serves to document and formalize all of Montrose's QA efforts. The manual is constantly updated, and each employee involved in technical services for emission measurements is required to read, understand its contents, and sign a statement that all work they perform will conform to its practices. The manual includes details on the other seven QA areas discussed below.

QA Reviews. Montrose's review procedure includes review of each source test report by the QA Manager or equivalent position including data input, calculations and averages, and report text. The laboratory manager or equivalent reviews all laboratory work, and the qualified individual on-site reviews all field work and data sheets.

The most important review is the one that takes place before a test program begins. The QA Manager works with testing personnel to prepare and review test protocols. Test protocol review includes selection of appropriate test procedures, evaluation of any interferences or other restrictions that might preclude use of standard test procedures, and evaluation and/or development of alternate procedures.

Equipment Calibration and Maintenance. The equipment used to conduct the emission measurements is maintained according to the manufacturer's instructions to ensure proper operation. In addition to the maintenance program, calibrations are carried out on each measurement device according to the schedule outlined below. The schedules for maintenance and calibrations are given in Tables A-1 and A-2.

Quality control checks are also conducted in the field for each test program. A partial list of checks made as part of each continuous analyzer system test series is included below as an example of the field QA procedures.

- Sample acquisition and conditioning system leak check
- 3-point analyzer calibrations (all analyzers)
- Complete system calibration check ("dynamic calibration" through entire sample system)

- Periodic analyzer calibration checks are conducted at the start and end of each test run. Any change between pre- and post-test readings are recorded.
- All calibrations are conducted using EPA Protocol gases certified by the manufacturer
- Calibration and continuous analyzer performance data are fully documented, and are included in each source test report

Chain of Custody. Montrose maintains full chain of custody documentation on all samples and data sheets. In addition to normal documentation of changes between field sample custodians, laboratory personnel, and field test personnel, Montrose documents every individual who handles any test component in the field (e.g., probe wash, impinger loading and recovery, filter loading and recovery, etc.).

Samples are stored in a locked area to which only laboratory personnel have access. Neither other Montrose employees nor cleaning crews have keys to this area.

Training. Personnel training is essential to ensure quality testing. Montrose has formal and informal training programs which may include some or all of the following:

1. Attendance at EPA-sponsored training courses
2. A requirement for all technicians to read, understand, and sign Montrose 's QA Manual
3. In-house training and Montrose meetings on a regular basis
4. Maintenance of training records
5. Administration of internal qualified individual (QI) tests for all methods performed
6. Participation in the Qualified Source Testing Individual (QSTI) program administered by the Source Evaluation Society (SES)

Knowledge of Current Test Methods. With the constant updating of standard test methods and the wide variety of emerging test methods, it is essential that any qualified source tester keep abreast of new developments. Montrose subscribes to services which provide updates on EPA reference methods, and on EPA and local agency rules and regulations. Additionally, source test personnel regularly attend and present papers at testing and emission-related seminars and conferences.

Audit Program. Montrose participates in the TNI Stationary Source Audit Sample (SSAS) audit program for all methods for which audit samples are available.

TABLE A-1
SAMPLING INSTRUMENTS AND
EQUIPMENT CALIBRATION SCHEDULE

Instrument Type	Frequency of Calibration ¹	Standard of Comparison or Method of Calibration	Acceptance Limits
Orifice Meter(large)	12 months	Calibrated dry test meter	± 2% of volume measured
Dry Gas Meter	6 months or when repaired	Calibrated dry test meter	± 2% of volume measured
Critical Orifice	6 months	Calibrated dry test meter	± 0.5% of average K'
S-Type Pitot (for use with EPA-type sampling train)	6 months	EPA Method 2	Geometric measurements within method-specified ranges
Vacuum Gauges	12 months	NIST-traceable gauge	≤ 1.0 in Hg difference
Temperature Measurement (thermocouples)	12 months	NBS mercury thermometer or NBS calibrated platinum RTD	±4 °F for <400 °F ± 1.5% for >400 °F
Temperature Readout Devices	6 months	Thermocouple simulator	± 2% full scale reading
Analytical Balance	12 months (check prior to each use)	NIST-traceable weights	± 0.5 mg of stated weight
Probe Nozzles	12 months	Nozzle diameter check	Range ≤± 0.10 mm for micrometer three measurements
Continuous Analyzers	Every field day, Depends upon use, frequency and performance	As specified by manufacturers' operating manuals, EPA NBS gases and/or reference methods	Satisfy all limits specified in operating specifications

¹ The tabulated calibration frequencies are minimum standards. In certain instances, calibrations are performed more frequently.

TABLE A-2
EQUIPMENT MAINTENANCE SCHEDULE
Based on Manufacturer's Specifications and Montrose's Experience

Equipment	Performance Requirement	Maintenance Interval ²	Corrective Action
Pumps	1. Absence of leaks 2. Ability to draw manufacturer required vacuum and flow	6 months	1. Visual inspection 2. Clean 3. Replace worn parts 4. Leak check
Flow Measuring Device	1. Free mechanical movement 2. Absence of malfunction	6 months	1. Visual inspection 2. Clean 3. Calibrate
Sampling Instruments	1. Absence of malfunction 2. Proper response to zero, span gas	As required by the manufacturer	As recommended by manufacturer
Mobile Van Sampling Systems	Absence of leaks	Depends on nature of use	1. Change filters 2. Leak check 3. Check for system contamination
Sampling Lines	Sample degradation less than 2%	After each test or test series	Blow filtered air through line until dry

² The tabulated maintenance intervals are minimum standards. In certain instances, maintenance is performed more frequently.

Bloom Energy
2022 Engineering Source Test Report

THIS IS THE LAST PAGE OF THIS DOCUMENT

If you have any questions, please contact one of the following individuals by email or phone.

Name: Finnegan Schall
Title: Client Project Manager
Region: West
Email: fschall@montrose-env.com
Phone: 913-530-4713

Name: Max Jakovleski
Title: District Manager
Region: West
Email: mpjakovleski@montrose-env.com
Phone: 925-750-0326

The Bloom Energy Server 5

Using solid oxide fuel cell technology, Bloom Energy Servers convert natural gas, biogas, or hydrogen into electricity at high efficiency and without combustion, significantly reducing environmental impacts.

Bloom Energy's solid oxide fuel cell (SOFC) platform provides an electrochemical pathway to convert fuel directly to electricity without combustion. Our systems can run on natural gas, biogas, and hydrogen, and our modular platform approach provides a pathway to upgrade existing systems to align with the sustainability goals of our customers over time.

Bloom is working with two leading non-profit organizations, MiQ and Equitable Origin, to help set a responsible standard for sourcing natural gas. Responsibly sourced gas is natural gas whose production has been evaluated across a range of stringent social, environmental, and governance criteria, including climate, community, and labor issues, to ensure that the highest standards and best practices were used to minimize greenhouse gases across its entire value chain.



Clean

Our systems produce near zero criteria pollutants (NO_x, SO_x, and particulate matter) and far fewer carbon emissions than legacy technologies.



Reliable

Bloom Energy Servers are designed around a modular architecture of simple repeating elements. This enables us to generate power 24 x 7 x 365 and can be configured to eliminate the need for traditional backup power equipment.



Resilient

Our system operates at very high availability due to their fault-tolerant design and use of the robust natural gas pipeline system. Bloom Energy Servers have survived extreme weather events and other incidences and have continued providing power to our customers.



Simple Installation and Maintenance

Our Energy Servers are 'plug and play' and have been designed in compliance with a variety of safety standards. Bloom Energy manages all aspects of installation, operation and maintenance of the systems.

Specifications

Outputs

Nameplate power output (net AC) — 300 kW
 Load output (net AC) — 300 kW
 Electrical connection — 480V, 3-phase, 60 Hz

Inputs

Fuels — Natural gas, directed biogas
 Input fuel pressure — 10–18 psig (15 psig nominal)
 Water — None during normal operation

Efficiency

Cumulative electrical efficiency (LHV net AC)¹ — 65–53%
 Heat rate (HHV) — 5,811–7,127 Btu/kWh

Emissions²

NOx — 0.0017 lbs/MWh
 SOx — Negligible
 CO — 0.012 lbs/MWh
 VOCs — 0.01 lbs/MWh
 CO₂ @ stated efficiency — 679–833 lbs/MWh on natural gas;
 carbon neutral on directed biogas

¹ 65% LHV efficiency verified by ASME PTC 50 Fuel Cell Power Systems Performance Test

² NOx and CO measured per CARB Method 100, VOCs measured as hexane by SCAQMD Method 25.3

Physical Attributes and Environment

Weight — 15.8 tons
 Dimensions (variable layouts) — 17'11" x 8'8" x 6'9" or
 32'3" x 4'4" x 7'2"
 Temperature range — -20° to 45° C
 Humidity — 0%–100%
 Seismic vibration — IBC site class D
 Location — Outdoor
 Noise — <70 dBA @ 6 feet

Codes and Standards

Complies with Rule 21 interconnection and IEEE1547 standards.

Exempt from CA Air District permitting; meets stringent CARB 2007 emissions standards.

An Energy Server is a Stationary Fuel Cell Power System. It is Listed by Underwriters Laboratories, Inc. (UL) as a 'Stationary Fuel Cell Power System' to ANSI/CSA FC1-2014 under UL Category IRGZ and UL File Number MH45102.

Additional Notes

Access to a secure website to monitor system performance & environmental benefits. Remotely managed and monitored by Bloom Energy. Capable of emergency stop based on input from the site.



Bloom Energy Headquarters
 4353 North First Street
 San Jose, CA 95134 USA

bloomenergy.com

Flexible. Future Proof.

Accelerate your path to a
 zero-carbon future.



March 25, 2021

Ms. Marisa Blackshire
Bloom Energy
Senior Director, Environmental Compliance and EH&S
4353 North First Street
San Jose, CA 95134

Subject: 2021 Emissions Tests – ES5 fired on Natural Gas
Document Number W005AS-006509-RT-1458

Dear Ms. Blackshire:

Montrose Air Quality Services, LLC (Montrose) was contracted by Bloom Energy, Inc. (Bloom) to conduct a series of emissions tests at the facility in San Jose, California. The sampling, analysis, and calculation of the results have been conducted to provide information for in-house engineering purposes. The testing program included one set of three samples collected on January 27, 2021 from one sampling location.

Supplemental data are provided in the appendices. Appendix A presents the field data sheets. Appendix B contains our quality assurance summary and certifications. Appendix C includes the laboratory analysis.

If you have questions or other concerns, please contact us. Thank you for using Montrose for your testing needs. We appreciate your confidence in our services and we welcome your comments. Please do not hesitate to call our Antioch office at (925) 680-4300 if you have any questions or we may be of additional service.

Sincerely,

A handwritten signature in black ink, appearing to read "P. Switzer", is placed above the printed name.

Patrick Switzer
Reporting / QC Specialist
Montrose Air Quality Services, LLC

Bloom Energy – ES-05 fired on Natural Gas
2021 Engineering Report

REVIEW AND CERTIFICATION

All work, calculations, and other activities and tasks performed and presented in this document were carried out by me or under my direction and supervision. I hereby certify that, to the best of my knowledge, Montrose operated in conformance with the requirements of the Montrose Quality Management System and ASTM D7036-04 during this test project.

Signature:  Date: 03 / 25 / 2021

Name: Finn Schall Title: Project Manager

I have reviewed, technically and editorially, details calculations, results, conclusions, and other appropriate written materials contained herein. I hereby certify that, to the best of my knowledge, the presented material is authentic, accurate, and conforms to the requirements of the Montrose Quality Management System and ASTM D7036-04.

Signature:  Date: 03 / 25 / 2021

Name: Dan Duncan Title: Reporting Hub Manager

Bloom Energy – ES-05 fired on Natural Gas
2021 Engineering Report

The sampling and analysis were conducted at a location, at a time, and using methods that meet the requirements of 40 CFR 60, as cited below.

Sampling: Each sample was collected using six-Liter Summa canisters at the exhaust stack of the unit. Measurements of the sampling location are included in the Appendix.

Analysis: The results of the analysis are presented in Tables 1 and 2.

Bloom Energy – ES-05 fired on Natural Gas
2021 Engineering Report

TABLE 1
RESULTS SUMMARY
GASEOUS EMISSIONS
BLOOM ENERGY
ES-5 FUEL POWER CELL – NATURAL GAS

Run Number:	1-NG	2-NG	3-NG	Average
Date:	1/27/21	1/27/21	1/27/21	--
Time:	1300-1400	1417-1517	1527-1627	--
Process Data:				
Energy production (A/C), KW	55.5	55.4	55.5	55.5
Energy production (D/C), KW	60.3	60.1	60.1	60.2
Flue Gas:				
O ₂ , % volume dry	13.9	13.9	13.7	13.8
CO ₂ , % volume dry	4.1	4.3	4.3	4.2
Flue gas temperature °F	333	335	333	334
Moisture content, % volume	8.3	8.6	8.3	8.4
Volumetric flow rate, dscfm	93.2	94.6	93.1	93.6
Benzene Emissions:				
ppm volume dry	1.18E-03	<i>4E-04</i>	<i>4E-04</i>	6.65E-04
lb/hr	1.33E-06	<i>4E-07</i>	<i>5E-07</i>	7.53E-07
lb/MWh	2.40E-05	<i>8E-06</i>	<i>9E-06</i>	1.36E-05
Toluene Emissions:				
ppm volume dry	4.72E-03	<i>4E-04</i>	<i>4E-04</i>	1.85E-03
lb/hr	6.28E-06	<i>5E-07</i>	<i>6E-07</i>	2.46E-06
lb/MWh	1.13E-04	<i>1E-05</i>	<i>1E-05</i>	4.43E-05
m & p-Xylene Emissions:				
ppm volume dry	1.67E-03	<i>8E-04</i>	<i>9E-04</i>	1.10E-03
lb/hr	2.56E-06	<i>1E-06</i>	<i>1E-06</i>	1.70E-06
lb/MWh	4.62E-05	<i>2E-05</i>	<i>2E-05</i>	3.06E-05

Note: lb/MWh calculations done using A/C power. Results in italics were found to be below the limit of detection reporting by the lab and have been calculated using ½ of the detection limit.

Bloom Energy – ES-05 fired on Natural Gas
2021 Engineering Report

TABLE 2
RESULTS SUMMARY
GASEOUS EMISSIONS
BLOOM ENERGY
ES-5 FUEL POWER CELL – NATURAL GAS

Run Number:	1-NG	2-NG	3-NG	Average
Date:	1/27/21	1/27/21	1/27/21	--
Time:	1300-1400	1417-1517	1527-1627	--
Process Data:				
Energy production (A/C), KW	55.5	55.4	55.5	55.5
Energy production (D/C), KW	60.3	60.1	60.1	60.2
Flue Gas:				
O ₂ , % volume dry	13.9	13.9	13.7	13.8
CO ₂ , % volume dry	4.1	4.3	4.3	4.2
Flue gas temperature °F	333	335	333	334
Moisture content, % volume	8.3	8.6	8.3	8.4
Volumetric flow rate, dscfm	93.2	94.6	93.1	93.6
Methanol Emissions:				
ppm volume dry	6.46E-02	<i>4E-03</i>	1.31E-02	2.72E-02
lb/hr	2.99E-05	<i>2E-06</i>	6.06E-06	1.26E-05
lb/MWh	5.39E-04	<i>3E-05</i>	1.09E-04	2.27E-04
Acetone Emissions:				
ppm volume dry	4.75E-03	<i>2E-03</i>	<i>2E-03</i>	2.67E-03
lb/hr	3.99E-06	<i>1E-06</i>	<i>1E-06</i>	2.25E-06
lb/MWh	7.19E-05	<i>2E-05</i>	<i>3E-05</i>	4.06E-05
Carbon Disulfide Emissions:				
ppm volume dry	<i>2E-03</i>	<i>2E-03</i>	4.08E-03	2.41E-03
lb/hr	<i>2E-06</i>	<i>2E-06</i>	4.49E-06	2.66E-06
lb/MWh	<i>3E-05</i>	<i>3E-05</i>	8.09E-05	4.80E-05
2-Butanone (MEK) Emissions:				
ppm volume dry	1.67E-03	<i>8E-04</i>	<i>9E-04</i>	1.10E-03
lb/hr	1.74E-06	<i>8E-07</i>	<i>9E-07</i>	1.15E-06
lb/MWh	3.14E-05	<i>1E-05</i>	<i>2E-05</i>	2.08E-05

Note: lb/MWh calculations done using A/C power. Results in italics were found to be below the limit of detection reporting by the lab and have been calculated using ½ of the detection limit.

Bloom Energy – ES-05 fired on Natural Gas
2021 Engineering Report

Montrose is qualified to conduct this test program and has established a quality management system that led to accreditation with ASTM Standard D7036-04 (Standard Practice for Competence of Air Emission Testing Bodies). Montrose participates in annual functional assessments for conformance with D7036-04 which are conducted by the American Association for Laboratory Accreditation (A2LA). All testing performed by Montrose is supervised on site by at least one Qualified Individual (QI) as defined in D7036-04 Section 8.3.2. Data quality objectives for estimating measurement uncertainty within the documented limits in the test methods are met by using approved test protocols for each project as defined in D7036-04 Sections 7.2.1 and 12.10. Additional quality assurance information is included in the report appendices.

Bloom Energy – ES-05 fired on Natural Gas
2021 Engineering Report

APPENDIX A

FIELD DATA SHEETS

SOURCE TEST DATA SUMMARY				
Client.....				Bloom
Unit / Location.....				ES-05
Stack area, square feet.....				0.180
Reference temperature, °F.....				70
Test number.....	1-NG	2-NG	3-NG	Average
Date.....	1/27/21	1/27/21	1/27/21	--
Start / Stop time.....	1300-1400	1417-1517	1527-1627	--
FUEL DATA				
Energy produced (A/C), KW.....	55.5	55.4	55.5	55.5
Energy produced (D/C), KW.....	60.3	60.1	60.1	60.2
SAMPLE TRAIN DATA				
Meter box number/ID.....	CB-15	CB-15	CB-15	--
Pitot coefficient	0.99	0.99	0.99	0.99
Meter calibration, Yd.....	0.992	0.976	0.976	0.981
Barometric pressure, in Hg.....	29.75	29.75	29.75	29.75
Meter box volume, acf.....	21.818	21.697	21.596	21.704
Impinger liquid volume, mL.....	42.1	43.6	41.0	42.2
Meter temperature, °F.....	61.0	52.7	57.8	57.1
Meter pressure, (Delta H) iwg.....	1.8	1.8	1.8	1.8
Velocity head, (Delta P) iwg.....	0.0296	0.0307	0.0296	0.0300
Static pressure, iwg.....	-0.05	-0.05	-0.05	-0.05
Stack temperature, °F.....	333	335	333	334
ANALYZER DATA				
O ₂ % volume dry.....	13.9	13.9	13.7	13.8
CO ₂ % volume dry.....	4.1	4.3	4.3	4.2
CO emissions, ppm volume dry.....	2.300	2.339	2.440	2.360
NO _x emissions, ppm volume dry.....	0.358	0.352	0.357	0.356
SO ₂ emissions, ppm volume dry.....	ND	ND	ND	ND
NO emissions, ppm volume dry.....	0.152	0.169	0.182	0.168
LAB ANALYSIS - SCAQMD 25.3				
VOC emissions as methane, ppm volume dry.....	3.4	5.2	4.0	4.2
LAB ANALYSIS				
Benzene emissions, ppb volume dry.....	1.18	0.8	0.9	0.9
Toluene emissions, ppb volume dry.....	4.72	0.8	0.9	2.1
m & p-Xylene, ppb volume dry.....	1.67	1.6	1.7	1.6
Methanol emissions, ppb volume dry.....	64.60	7.9	13.10	28.5
Acetone emissions, ppb volume dry.....	4.75	3.1	3.4	3.8
Carbon Disulfide emissions, ppb volume dry.....	3.2	3.1	4.08	3.5
2-Butanone (MEK), ppb volume dry.....	1.67	1.6	1.7	1.6
VOLUMETRIC FLOW RATE				
^{1a} Standard sample volume, dscf.....	21.990	21.865	21.549	21.801
^{1b} Water vapor volume, scf.....	1.9925	2.0635	1.9405	1.9988
^{1c} Moisture fraction, nondimensional.....	0.0831	0.0862	0.0826	0.0840
^{1d} Stack gas molecular weight, dry.....	29.213	29.245	29.229	29.229
^{1e} Stack gas molecular weight, wet.....	28.281	28.276	28.301	28.286
^{1f} Absolute stack pressure, in Hg.....	29.746	29.746	29.746	29.746
^{1g} Stack gas velocity, ft/sec.....	14.128	14.420	14.128	14.225
^{1h} Stack flow rate, acfm.....	152.9	156.0	152.9	153.9
¹ⁱ Stack Flow Rate (wscfm).....	101.6	103.5	101.5	102.2
^{1j} Stack flow rate - based on pitot, dscfm.....	93.2	94.6	93.1	93.6
EMISSIONS				
Benzene concentrations, ppm volume dry.....	1.18E-03	4E-04	4E-04	6.65E-04
Benzene mass emissions, lb/hr.....	1.33E-06	4E-07	5E-07	7.53E-07
Benzene mass emissions, lb/MWh (AC power).....	2.40E-05	8E-06	9E-06	1.36E-05
Toluene concentrations, ppm volume dry.....	4.72E-03	4E-04	4E-04	1.85E-03
Toluene mass emissions, lb/hr.....	6.28E-06	5E-07	6E-07	2.46E-06
Toluene mass emissions, lb/MWh (AC power).....	1.13E-04	1E-05	1E-05	4.43E-05
m & p-Xylene concentrations, ppm volume dry.....	1.67E-03	8E-04	9E-04	1.10E-03
m & p-Xylene mass emissions, lb/hr.....	2.56E-06	1E-06	1E-06	1.70E-06
m & p-Xylene mass emissions, lb/MWh (AC power).....	4.62E-05	2E-05	2E-05	3.06E-05
Methanol concentrations, ppm volume dry.....	6.46E-02	4E-03	1.31E-02	2.72E-02
Methanol mass emissions, lb/hr.....	2.99E-05	2E-06	6.06E-06	1.26E-05
Methanol mass emissions, lb/MWh (AC power).....	5.39E-04	3E-05	1.09E-04	2.27E-04
Acetone concentrations, ppm volume dry.....	4.75E-03	2E-03	2E-03	2.67E-03
Acetone mass emissions, lb/hr.....	3.99E-06	1E-06	1E-06	2.25E-06
Acetone mass emissions, lb/MWh (AC power).....	7.19E-05	2E-05	3E-05	4.06E-05
Carbon Disulfide concentrations, ppm volume dry.....	2E-03	2E-03	4.08E-03	2.41E-03
Carbon Disulfide mass emissions, lb/hr.....	2E-06	2E-06	4.49E-06	2.66E-06
Carbon Disulfide mass emissions, lb/MWh (AC power).....	3E-05	3E-05	8.09E-05	4.80E-05
2-Butanone (MEK) concentrations, ppm volume dry.....	1.67E-03	8E-04	9E-04	1.10E-03
2-Butanone (MEK) mass emissions, lb/hr.....	1.74E-06	8E-07	9E-07	1.15E-06
2-Butanone (MEK) mass emissions, lb/MWh (AC power).....	3.14E-05	1E-05	2E-05	2.08E-05

Notes: lb/MWh calculations done using A/C power. Results in italics were found to be below the limit of detection reporting by the lab and have been calculated using 1/2 of the detection

001AS-QMS



Sample Recovery & Calibration Check Datasheet

Page 1 of 1

Project Information		Equipment Identification	
Date <u>1-27-21</u>	Project # <u>005AS-006509</u>	Ref. Thermometer	
Customer / Facility <u>Bloom Energy</u>		Hygrometer	
Unit ID / Sample Location <u>NG</u>		Field Balance <u>8-AB-OAK</u>	
Run # <u>1-3</u>	Operator <u>JR/kA</u>	Check Weights <u>W-6</u>	
		Calipers	

Balance Audit (Field balance must be within 0.5g of check weight mass)		Ambient Conditions (Mobile Lab)	
Date <u>1-27-21</u>		Relative humidity, %	
Standard mass, g <u>500.0</u>		Temperature, °F	
Field balance mass, g <u>499.7</u>		Mobile lab #	

Moisture Determination										
Contents	Run 1			Run 2			Run 3			
	Initial	Final	Net	Initial	Final	Net	Initial	Final	Net	
Knockout										
Impinger 1	<u>DI</u>	<u>699.6</u>	<u>735.6</u>	<u>36.0</u>	<u>727.2</u>	<u>764.8</u>	<u>37.6</u>	<u>728.2</u>	<u>764.6</u>	<u>36.4</u>
Impinger 2	<u>DI</u>	<u>662.8</u>	<u>664.3</u>	<u>1.5</u>	<u>663.4</u>	<u>663.9</u>	<u>0.5</u>	<u>665.7</u>	<u>666.3</u>	<u>0.6</u>
Impinger 3	<u>Empty</u>	<u>616.3</u>	<u>616.8</u>	<u>0.5</u>	<u>500.4</u>	<u>500.8</u>	<u>0.4</u>	<u>616.8</u>	<u>616.9</u>	<u>0.1</u>
Impinger 4	<u>Silica Gel</u>	<u>951.7</u>	<u>955.8</u>	<u>4.1</u>	<u>953.8</u>	<u>958.9</u>	<u>5.1</u>	<u>937.9</u>	<u>941.8</u>	<u>3.9</u>
Impinger 5										
Impinger 6										
Impinger 7										
Impinger 8										
Silica Gel										
Line Rinse										
Train Net Gain (Vlc)			<u>42.1</u>			<u>43.6</u>			<u>41.0</u>	

Nozzle Measurements (Difference between any two measurements must not be more than 0.004 in (0.1 mm))

Nozzle 1 diameters	D1	D2	D3	Average
Nozzle 2 diameters	D1	D2	D3	Average
Nozzle 3 diameters	D1	D2	D3	Average

Nozzle Material ☐ quartz ☐ glass ☐ steel ☐ titanium ☐ Inconel ☐ other

Probe Type ☐ heated ☐ unheated ☐ air-cooled ☐ water-cooled ☐ other

Probe Liner ☐ quartz ☐ glass ☐ steel ☐ Teflon ☐ other

Filter Information

Front Half: ☐ quartz fiber ☐ glass fiber ☐ Teflon ☐ Teflon/quartz ☐ other

Filter Number: Run 1: Run 2: Run 3: Run

Back Half: ☐ quartz fiber ☐ glass fiber ☐ Teflon ☐ Teflon/quartz ☐ other

Reagent Information	Sample Observations
Type	Lot Number

QA/QC Check: Completeness _____ Legibility _____ Accuracy _____ Specifications _____

Checked by: _____ Team Leader: _____

001AS-QMS-FM-226

Bloom Energy – ES-05 fired on Natural Gas
2021 Engineering Report

APPENDIX B

QUALITY ASSURANCE AND CALIBRATION DATA



American Association for Laboratory Accreditation

Accredited Air Emission Testing Body

A2LA has accredited

MONTROSE AIR QUALITY SERVICES

In recognition of the successful completion of the joint A2LA and Stack Testing Accreditation Council (STAC) evaluation process, this laboratory is accredited to perform testing activities in compliance with ASTM D7036:2004 - Standard Practice for Competence of Air Emission Testing Bodies.



Presented this 11th day of February 2020.

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 3925.01
Valid to February 28, 2022

This accreditation program is not included under the A2LA ILAC Mutual Recognition Arrangement.



Gavin Newsom, Governor
Jared Blumenfeld, CalEPA Secretary
Mary D. Nichols, Chair

July 1, 2020

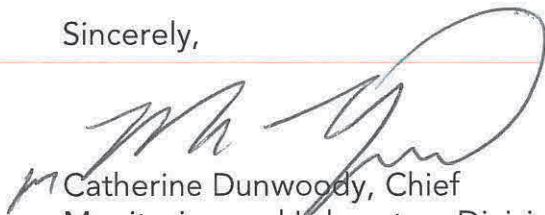
Mr. Matt McCune
Montrose Air Quality Services, LLC
1631 East Saint Andrew Place
Santa Ana, California 92705

Dear Mr. McCune:

I am pleased to inform you that the California Air Resources Board (CARB) has renewed, by means of enclosed Executive Order I-20-008, Montrose Air Quality Services, LLC to perform CARB Test Methods 1, 2, 3, 4, 5, 6, 8, 17, 20, and 100 (CO, CO₂, NO_x, O₂, SO₂, THC), Visible Emission Evaluation, and U.S. Environmental Protection Agency Test Methods 201A, 202, and 205. These approvals are valid through June 30, 2022, during which time additional audits of Montrose Air Quality Services, LLC's testing ability may be performed.

If you have questions or need further assistance, please contact Kathryn Gugeler at kathryn.gugeler@arb.ca.gov or Christopher Dilbeck at christopher.dilbeck@arb.ca.gov.

Sincerely,



Catherine Dunwoody, Chief
Monitoring and Laboratory Division

Enclosure

cc: Christopher Dilbeck, Manager
Testing and Certification Section

Kathryn Gugeler
Monitoring and Laboratory Division

**State of California
AIR RESOURCES BOARD**

EXECUTIVE ORDER I-20-008

**Approval of Independent Contractor Pursuant to
California Code of Regulations, title 17, section 91207**

Montrose Air Quality Services, LLC

WHEREAS, the California Air Resources Board (CARB), pursuant to California Health and Safety Code, section 41512, has established the procedures contained in California Code of Regulations, title 17, section 91200 and following, to allow the use of independent testers for compliance tests required by CARB;

WHEREAS, it has been determined that Montrose Air Quality Services, LLC meets the requirements of CARB for performing CARB Test Methods 1, 2, 3, 4, 5, 6, 8, 17, 20, and 100 (CO, CO₂, NO_x, O₂, SO₂, THC), Visible Emission Evaluation (VEE), and U.S. Environmental Protection Agency (U.S. EPA) Test Methods 201A, 202, and 205 pursuant to Cal. Code Regs., tit. 17, § 91200 and following, when the following conditions are met:

1. Montrose Air Quality Services, LLC permanently marks or engraves an identification number on the body of each of its pitot tubes in accordance with section 2.1 of CARB Test Method 2;
2. Montrose Air Quality Services, LLC calibrates its differential pressure gauges after each test series in accordance with section 2.2 of CARB Test Method 2, and establishes and maintains a log of the calibrations;
3. Montrose Air Quality Services, LLC calibrates its temperature gauges in accordance with section 4.3 of CARB Test Method 2, and establishes and maintains a log of the calibrations;
4. Montrose Air Quality Services, LLC calibrates its metering system in accordance with section 5.3 of CARB Test Method 5, and establishes and maintains a log of the calibrations;
5. Montrose Air Quality Services, LLC acquires and uses a 5-mL burette in accordance with section 2.3.3 of CARB Test Method 6 and section 4.2 of CARB Test Method 20;
6. Montrose Air Quality Services, LLC acquires and uses 300 to 500 mL glass beakers in accordance with Section 6.2.2(c) of U.S. EPA Test Method 202;
7. Montrose Air Quality Services, LLC uses desiccant in accordance with section 3.3.2 of CARB Test Methods 5 and 17, section 7.2.2 of U.S. EPA Test Method 201A, and section 7.2.4 of U.S. EPA Test Method 202;

-2-

8. The person performing VEE passed CARB Compliance Training Course #100: Fundamentals of Enforcement (FOE)/Visible Emissions Evaluation (Smoke School), or MM104: Visible Emissions Evaluation (Online) and MM105: Visible Emissions Evaluation (In Class), and is currently certified to conduct VEE. Any recertification for VEE, following the initial passage of CARB's FOE, must be from a certifying body recognized by CARB at the time VEE is performed; and

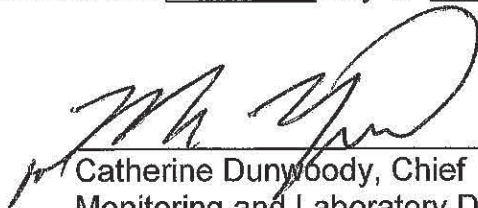
WHEREAS, CARB Executive Officer, pursuant to California Health and Safety Code Section 39516, issued Executive Order G-02-008, delegating to the Chief of CARB Monitoring and Laboratory Division (MLD) the authority to approve independent testers in accordance with Cal. Code Regs., tit. 17, § 91200 and following.

NOW, THEREFORE, I, Catherine Dunwoody, Chief of MLD, order that Montrose Air Quality Services, LLC is granted approval from the date of execution of this Executive Order through June 30, 2022, to perform the test methods identified above subject to compliance with Cal. Code Regs., tit. 17, § 91200 and following.

BE IT FURTHER ORDERED that during the approved period, the Executive Officer or his or her authorized representative may field audit one or more tests performed pursuant to this Executive Order for each test method identified above.

IT IS FURTHER ORDERED that Executive Order I-18-002 is superseded by this order.

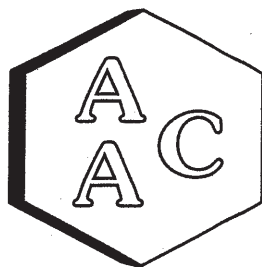
Executed at Sacramento, California this 1st day of July 2020.


Catherine Dunwoody, Chief
Monitoring and Laboratory Division

Bloom Energy – ES-05 fired on Natural Gas
2021 Engineering Report

APPENDIX C

LABORATORY ANALYSIS DATA



Atmospheric Analysis & Consulting, Inc.

CLIENT : Montrose Air Quality Services
PROJECT NAME : Bloom
PROJECT NO. : 005AS-006509
AAC PROJECT NO. : 210157
REPORT DATE : 2/5/2021

On January 29, 2021, Atmospheric Analysis & Consulting, Inc. received three (3) six-Liter Summa Canisters for Volatile Organic Compounds analysis by EPA Method TO-15. Upon receipt, the samples were assigned unique Laboratory ID numbers as follows:

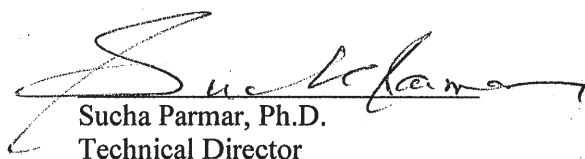
Client ID	Lab ID	Return Pressure (mmHg)
NG-TO 12 & 15-1	210157-16301	647.5
NG-TO 12 & 15-2	210157-16302	650.6
NG-TO 12 & 15-3	210157-16303	601.3

This analysis is accredited under the laboratory's ISO/IEC 17025:2017 accreditation issued by the ANSI National Accreditation Board. Refer to certificate and scope of accreditation AT-1908. Test results apply to the sample(s) as received. For detailed information pertaining to specific EPA, NCASI, ASTM and SCAQMD accreditations (Methods & Analytes), please visit our website at www.aaclab.com.

I certify that this data is technically accurate, complete, and in compliance with the terms and conditions of the contract. A few analytes were biased high as reflected in the daily CCV report; however, none of these analytes were detected in the samples. No problems were encountered during receiving, preparation, and/or analysis of these samples.

The Technical Director or his designee, as verified by the following signature, has authorized release of the data contained in this hardcopy report.

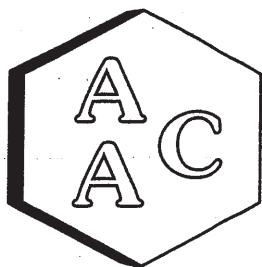
If you have any questions or require further explanation of data results, please contact the undersigned.


Sucha Parmar, Ph.D.
Technical Director

This report consists of 11 pages.

Page 1





Atmospheric Analysis & Consulting, Inc.

Laboratory Analysis Report

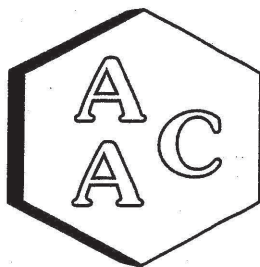
CLIENT : Montrose Air Quality Services
 PROJECT NO : 210157
 MATRIX : AIR
 UNITS : PPB (v/v)

DATE RECEIVED : 01/29/2021
 DATE REPORTED : 02/05/2021
 ANALYST : MB/RC

VOLATILE ORGANIC COMPOUNDS BY EPA TO-15

Client ID	NG-TO 12 & 15-1			Sample Reporting Limit (SRL) (MRLxDF's)	NG-TO 12 & 15-2			Sample Reporting Limit (SRL) (MRLxDF's)	Method Reporting Limit (MRL)
AAC ID	210157-16301				210157-16302				
Date Sampled	01/27/2021				01/27/2021				
Date Analyzed	02/04/2021				02/04/2021				
Can Dilution Factor	1.58				1.57				
Compound	Result	Qualifier	Analysis DF		Result	Qualifier	Analysis DF		
Chlorodifluoromethane	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5
Propene	<SRL	U	1	1.58	<SRL	U	1	1.57	1.0
Dichlorodifluoromethane	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5
Chloromethane	<SRL	U	1	1.58	<SRL	U	1	1.57	1.0
Dichlorotetrafluoroethane	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5
Vinyl Chloride	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5
Methanol	64.6		1	7.89	<SRL	U	1	7.85	5.0
1,3-Butadiene	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5
Bromomethane	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5
Chloroethane	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5
Dichlorofluoromethane	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5
Ethanol	<SRL	U	1	3.16	<SRL	U	1	3.14	2.0
Vinyl Bromide	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5
Acetone	4.75		1	3.16	<SRL	U	1	3.14	2.0
Trichlorofluoromethane	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5
2-Propanol (IPA)	<SRL	U	1	3.16	<SRL	U	1	3.14	2.0
Acrylonitrile	<SRL	U	1	3.16	<SRL	U	1	3.14	2.0
1,1-Dichloroethene	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5
Methylene Chloride (DCM)	<SRL	U	1	1.58	<SRL	U	1	1.57	1.0
Allyl Chloride	<SRL	U	1	1.58	<SRL	U	1	1.57	1.0
Carbon Disulfide	<SRL	U	1	3.16	<SRL	U	1	3.14	2.0
Trichlorotrifluoroethane	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5
trans-1,2-Dichloroethene	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5
1,1-Dichloroethane	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5
Methyl Tert Butyl Ether (MTBE)	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5
Vinyl Acetate	<SRL	U	1	1.58	<SRL	U	1	1.57	1.0
2-Butanone (MEK)	1.67		1	1.58	<SRL	U	1	1.57	1.0
cis-1,2-Dichloroethene	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5
Hexane	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5
Chloroform	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5
Ethyl Acetate	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5
Tetrahydrofuran	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5
1,2-Dichloroethane	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5
1,1,1-Trichloroethane	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5
Benzene	1.18		1	0.79	<SRL	U	1	0.78	0.5





Atmospheric Analysis & Consulting, Inc.

Laboratory Analysis Report

CLIENT : Montrose Air Quality Services
 PROJECT NO : 210157
 MATRIX : AIR
 UNITS : PPB (v/v)

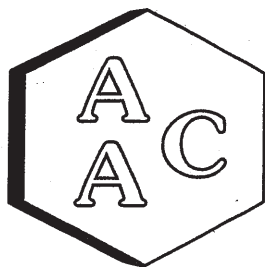
DATE RECEIVED : 01/29/2021
 DATE REPORTED : 02/05/2021
 ANALYST : MB/RC

VOLATILE ORGANIC COMPOUNDS BY EPA TO-15

Client ID	NG-TO 12 & 15-1				Sample Reporting Limit (SRL) (MRLxDF's)	NG-TO 12 & 15-2			Sample Reporting Limit (SRL) (MRLxDF's)	Method Reporting Limit (MRL)
AAC ID	210157-16301					210157-16302				
Date Sampled	01/27/2021					01/27/2021				
Date Analyzed	02/04/2021					02/04/2021				
Can Dilution Factor	1.58					1.57				
Compound	Result	Qualifier	Analysis DF			Result	Qualifier	Analysis DF		
Carbon Tetrachloride	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
Cyclohexane	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
1,2-Dichloropropane	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
Bromodichloromethane	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
1,4-Dioxane	<SRL	U	1	1.58	<SRL	U	1	1.57	1.0	
Trichloroethene (TCE)	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
2,2,4-Trimethylpentane	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
Heptane	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
cis-1,3-Dichloropropene	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
4-Methyl-2-pentanone (MiBK)	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
trans-1,3-Dichloropropene	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
1,1,2-Trichloroethane	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
Toluene	4.72		1	0.79	<SRL	U	1	0.78	0.5	
2-Hexanone (MBK)	<SRL	U	1	1.58	<SRL	U	1	1.57	1.0	
Dibromochloromethane	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
1,2-Dibromoethane	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
Tetrachloroethene (PCE)	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
Chlorobenzene	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
Ethylbenzene	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
m & p-Xylene	1.67		1	1.58	<SRL	U	1	1.57	1.0	
Bromoform	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
Styrene	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
1,1,2,2-Tetrachloroethane	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
o-Xylene	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
4-Ethyltoluene	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
1,3,5-Trimethylbenzene	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
1,2,4-Trimethylbenzene	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
Benzyl Chloride (a-Chlorotoluene)	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
1,3-Dichlorobenzene	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
1,4-Dichlorobenzene	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
1,2-Dichlorobenzene	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
1,2,4-Trichlorobenzene	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
Hexachlorobutadiene	<SRL	U	1	0.79	<SRL	U	1	0.78	0.5	
BFB-Surrogate Std. % Recovery		102%				100%			70-130%	

U - Compound was not detected at or above the SRL.





Atmospheric Analysis & Consulting, Inc.

Laboratory Analysis Report

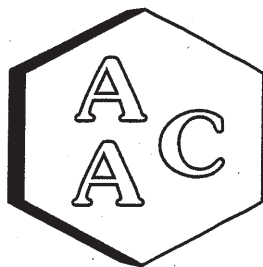
CLIENT : Montrose Air Quality Services
 PROJECT NO : 210157
 MATRIX : AIR
 UNITS : PPB (v/v)

DATE RECEIVED : 01/29/2021
 DATE REPORTED : 02/05/2021
 ANALYST : MB/RC

VOLATILE ORGANIC COMPOUNDS BY EPA TO-15

Client ID	NG-TO 12 & 15-3			Sample Reporting Limit (SRL) (MRLxDf's)	Method Reporting Limit (MRL)
AAC ID	210157-16303				
Date Sampled	01/27/2021				
Date Analyzed	02/04/2021				
Canister Dilution Factor	1.70				
Compound	Result	Qualifier	Analysis DF		
Chlorodifluoromethane	<SRL	U	1	0.85	0.5
Propene	<SRL	U	1	1.70	1.0
Dichlorodifluoromethane	<SRL	U	1	0.85	0.5
Chloromethane	<SRL	U	1	1.70	1.0
Dichlorotetrafluoroethane	<SRL	U	1	0.85	0.5
Vinyl Chloride	<SRL	U	1	0.85	0.5
Methanol	13.1		1	8.50	5.0
1,3-Butadiene	<SRL	U	1	0.85	0.5
Bromomethane	<SRL	U	1	0.85	0.5
Chloroethane	<SRL	U	1	0.85	0.5
Dichlorofluoromethane	<SRL	U	1	0.85	0.5
Ethanol	<SRL	U	1	3.40	2.0
Vinyl Bromide	<SRL	U	1	0.85	0.5
Acetone	<SRL	U	1	3.40	2.0
Trichlorofluoromethane	<SRL	U	1	0.85	0.5
2-Propanol (IPA)	<SRL	U	1	3.40	2.0
Acrylonitrile	<SRL	U	1	3.40	2.0
1,1-Dichloroethene	<SRL	U	1	0.85	0.5
Methylene Chloride (DCM)	<SRL	U	1	1.70	1.0
Allyl Chloride	<SRL	U	1	1.70	1.0
Carbon Disulfide	4.08		1	3.40	2.0
Trichlorotrifluoroethane	<SRL	U	1	0.85	0.5
trans-1,2-Dichloroethene	<SRL	U	1	0.85	0.5
1,1-Dichloroethane	<SRL	U	1	0.85	0.5
Methyl Tert Butyl Ether (MTBE)	<SRL	U	1	0.85	0.5
Vinyl Acetate	<SRL	U	1	1.70	1.0
2-Butanone (MEK)	<SRL	U	1	1.70	1.0
cis-1,2-Dichloroethene	<SRL	U	1	0.85	0.5
Hexane	<SRL	U	1	0.85	0.5
Chloroform	<SRL	U	1	0.85	0.5
Ethyl Acetate	<SRL	U	1	0.85	0.5
Tetrahydrofuran	<SRL	U	1	0.85	0.5
1,2-Dichloroethane	<SRL	U	1	0.85	0.5
1,1,1-Trichloroethane	<SRL	U	1	0.85	0.5
Benzene	<SRL	U	1	0.85	0.5





Atmospheric Analysis & Consulting, Inc.

Laboratory Analysis Report

CLIENT : Montrose Air Quality Services
 PROJECT NO : 210157
 MATRIX : AIR
 UNITS : PPB (v/v)

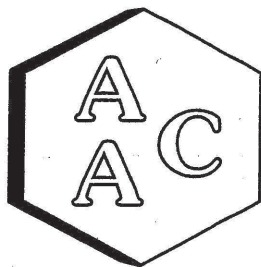
DATE RECEIVED : 01/29/2021
 DATE REPORTED : 02/05/2021
 ANALYST : MB/RC

VOLATILE ORGANIC COMPOUNDS BY EPA TO-15

Client ID	NG-TO 12 & 15-3			Sample Reporting Limit (SRL) (MRLxDF's)	Method Reporting Limit (MRL)
AAC ID	210157-16303				
Date Sampled	01/27/2021				
Date Analyzed	02/04/2021				
Canister Dilution Factor	1.70				
Compound	Result	Qualifier	Analysis DF		
Carbon Tetrachloride	<SRL	U	1	0.85	0.5
Cyclohexane	<SRL	U	1	0.85	0.5
1,2-Dichloropropane	<SRL	U	1	0.85	0.5
Bromodichloromethane	<SRL	U	1	0.85	0.5
1,4-Dioxane	<SRL	U	1	1.70	1.0
Trichloroethene (TCE)	<SRL	U	1	0.85	0.5
2,2,4-Trimethylpentane	<SRL	U	1	0.85	0.5
Heptane	<SRL	U	1	0.85	0.5
cis-1,3-Dichloropropene	<SRL	U	1	0.85	0.5
4-Methyl-2-pentanone (MiBK)	<SRL	U	1	0.85	0.5
trans-1,3-Dichloropropene	<SRL	U	1	0.85	0.5
1,1,2-Trichloroethane	<SRL	U	1	0.85	0.5
Toluene	<SRL	U	1	0.85	0.5
2-Hexanone (MBK)	<SRL	U	1	1.70	1.0
Dibromochloromethane	<SRL	U	1	0.85	0.5
1,2-Dibromoethane	<SRL	U	1	0.85	0.5
Tetrachloroethene (PCE)	<SRL	U	1	0.85	0.5
Chlorobenzene	<SRL	U	1	0.85	0.5
Ethylbenzene	<SRL	U	1	0.85	0.5
m & p-Xylene	<SRL	U	1	1.70	1.0
Bromoform	<SRL	U	1	0.85	0.5
Styrene	<SRL	U	1	0.85	0.5
1,1,2,2-Tetrachloroethane	<SRL	U	1	0.85	0.5
o-Xylene	<SRL	U	1	0.85	0.5
4-Ethyltoluene	<SRL	U	1	0.85	0.5
1,3,5-Trimethylbenzene	<SRL	U	1	0.85	0.5
1,2,4-Trimethylbenzene	<SRL	U	1	0.85	0.5
Benzyl Chloride (a-Chlorotoluene)	<SRL	U	1	0.85	0.5
1,3-Dichlorobenzene	<SRL	U	1	0.85	0.5
1,4-Dichlorobenzene	<SRL	U	1	0.85	0.5
1,2-Dichlorobenzene	<SRL	U	1	0.85	0.5
1,2,4-Trichlorobenzene	<SRL	U	1	0.85	0.5
Hexachlorobutadiene	<SRL	U	1	0.85	0.5
BFB-Surrogate Std. % Recovery		99%			70-130%

U - Compound was not detected at or above the SRL.





Atmospheric Analysis & Consulting, Inc.

QUALITY CONTROL / QUALITY ASSURANCE REPORT

ANALYSIS DATE : 02/04/2021

MATRIX : High Purity N₂

UNITS : PPB (v/v)

INSTRUMENT ID : GC/MS-03

CALIBRATION STD ID : PS011921-01

ANALYST : MB/RC

VOLATILE ORGANIC COMPOUNDS BY EPA METHOD TO-15

Continuing Calibration Verification of the 01/20/2021 Calibration

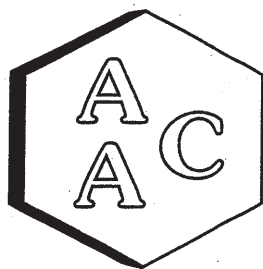
Analyte Compounds	Source ¹	CCV ²	% Recovery ³
4-BFB (surrogate standard)	10.00	10.41	104
Chlorodifluoromethane	10.70	9.11	85
Propene	11.00	9.23	84
Dichlorodifluoromethane	10.30	9.34	91
Dimethyl Ether	10.70	9.21	86
Chloromethane	10.60	7.74	73
Dichlorotetrafluoroethane	10.20	8.91	87
Vinyl Chloride	10.50	9.43	90
Acetaldehyde	19.80	19.27	97
Methanol	16.80	15.76	94
1,3-Butadiene	10.90	9.11	84
Bromomethane	HR 10.60	14.96	141
Chloroethane	10.20	7.99	78
Dichlorofluoromethane	10.40	8.92	86
Ethanol	10.20	8.48	83
Vinyl Bromide	10.60	9.09	86
Acrolein	11.00	9.91	90
Acetone	10.50	9.62	92
Trichlorofluoromethane	10.50	9.51	91
2-Propanol (IPA)	9.80	10.97	112
Acrylonitrile	11.50	10.24	89
1,1-Dichloroethene	10.80	10.96	101
Methylene Chloride (DCM)	10.90	9.18	84
TertButanol (TBA)	10.50	9.91	94
Allyl Chloride	HR 10.60	14.70	139
Carbon Disulfide	10.20	9.92	97
Trichlorotrifluoroethane	10.90	10.29	94
trans-1,2-Dichloroethene	10.30	9.43	92
1,1-Dichloroethane	10.40	9.73	94
Methyl Tert Butyl Ether (MTBE)	11.00	10.15	92
Vinyl Acetate	HR 11.00	14.90	135
2-Butanone (MEK)	10.60	10.40	98
cis-1,2-Dichloroethene	10.70	10.56	99
Hexane	11.00	11.31	103
Chloroform	10.80	9.79	91
Ethyl Acetate	10.80	10.37	96
Tetrahydrofuran	10.30	9.31	90
1,2-Dichloroethane	10.80	10.82	100
1,1,1-Trichloroethane	10.70	9.99	93
Benzene	10.80	10.49	97
Carbon Tetrachloride	10.80	11.30	105
Cyclohexane	10.80	11.24	104

Analyte Compounds (Continued)	Source ¹	CCV ²	% Recovery ³
1,2-Dichloropropane	10.80	11.04	102
Bromodichloromethane	9.90	10.40	105
1,4-Dioxane	9.90	10.55	107
Trichloroethene (TCE)	9.90	10.51	106
2,2,4-Trimethylpentane	10.70	10.02	94
Methyl Methacrylate	10.60	12.03	113
Heptane	10.80	11.48	106
cis-1,3-Dichloropropene	10.40	11.26	108
4-Methyl-2-pentanone (MIBK)	10.40	10.73	103
trans-1,3-Dichloropropene	10.20	10.71	105
1,1,2-Trichloroethane	10.90	11.30	104
Toluene	11.00	11.60	105
2-Hexanone (MBK)	10.10	11.16	110
Dibromochloromethane	10.40	10.91	105
1,2-Dibromoethane	10.90	11.90	109
Tetrachloroethene (PCE)	10.60	11.21	106
Chlorobenzene	10.80	10.87	101
Ethylbenzene	10.90	11.79	108
m & p-Xylene	21.20	22.83	108
Bromoform	10.60	11.18	105
Styrene	10.80	11.82	109
1,1,2,2-Tetrachloroethane	10.70	11.35	106
o-Xylene	10.70	11.44	107
1,2,3-Trichloropropane	10.70	11.42	107
Isopropylbenzene (Cumene)	10.70	11.00	103
α-Pinene	11.60	11.91	103
2-Chlorotoluene	10.70	10.99	103
n-Propylbenzene	10.10	11.55	114
4-Ethyltoluene	10.70	12.94	121
1,3,5-Trimethylbenzene	10.60	12.01	113
β-Pinene	HR 9.30	15.03	162
1,2,4-Trimethylbenzene	10.50	11.52	110
Benzyl Chloride (α-Chlorotoluene)	10.20	12.03	118
1,3-Dichlorobenzene	10.20	11.62	114
1,4-Dichlorobenzene	10.60	12.50	118
Sec-Butylbenzene	10.70	11.31	106
1,2-Dichlorobenzene	10.60	11.76	111
n-Butylbenzene	10.30	11.73	114
1,2-Dibromo-3-Chloropropane	10.20	10.83	106
1,2,4-Trichlorobenzene	10.90	12.31	113
Naphthalene	11.00	10.86	99
Hexachlorobutadiene	10.90	12.31	113

¹ Concentration of analyte compound in certified source standard.² Measured result from daily Continuing Calibration Verification (CCV).³ The acceptable range for analyte recovery is 100±30%.

HR - Recovery for this compound was high. Results should be consider biased high.





Atmospheric Analysis & Consulting, Inc.

QUALITY CONTROL / QUALITY ASSURANCE REPORT

ANALYSIS DATE : 02/04/2021

MATRIX : High Purity N₂

UNITS : PPB (v/v)

INSTRUMENT ID : GC/MS-03

CALIBRATION STD ID : PS011921-01

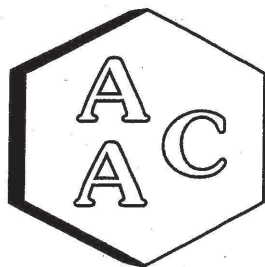
ANALYST : MB/RC

VOLATILE ORGANIC COMPOUNDS BY EPA METHOD TO-15

Laboratory Control Spike Analysis

System Monitoring Compounds	Sample Concentration	Spike Added	LCS ¹ Recovery	LCSD ¹ Recovery	LCS ¹ % Recovery ²	LCSD ¹ % Recovery ²	RPD ³
4-BFB (surrogate standard)	0.0	10.00	10.41	10.09	104.1	100.9	3.1
1,1-Dichloroethene	0.0	10.80	10.96	10.79	101	100	1.6
Methylene Chloride (DCM)	0.0	10.90	9.18	9.52	84	87	3.6
Benzene	0.0	10.80	10.49	9.95	97	92	5.3
Trichloroethene (TCE)	0.0	9.90	10.51	10.32	106	104	1.8
Toluene	0.0	11.00	11.60	11.96	105	109	3.1
Tetrachloroethene (PCE)	0.0	10.60	11.21	10.87	106	103	3.1
Chlorobenzene	0.0	10.80	10.87	11.00	101	102	1.2
Ethylbenzene	0.0	10.90	11.79	11.37	108	104	3.6
m & p-Xylene	0.0	21.20	22.83	21.75	108	103	4.8
o-Xylene	0.0	10.70	11.44	10.96	107	102	4.3

¹ Laboratory Control Spike (LCS) / Laboratory Control Spike Duplicate (LCSD)² The acceptable range for analyte recovery is 100±30%.³ Relative Percent Difference (RPD) between LCS recovery and LCSD recovery (acceptable range is <25%).



Atmospheric Analysis & Consulting, Inc.

QUALITY CONTROL / QUALITY ASSURANCE REPORT

ANALYSIS DATE : 02/04/2021

INSTRUMENT ID : GC/MS-03

MATRIX : High Purity He or N₂

ANALYST : MB/RC

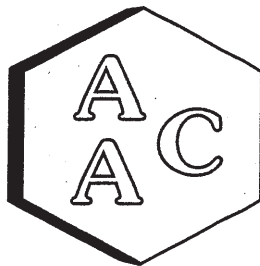
UNITS : PPB (v/v)

VOLATILE ORGANIC COMPOUNDS BY EPA METHOD TO-15

Method Blank Analysis

Analyte Compounds	MB 020421	Reporting Limit (RL)	Analyte Compounds (Continued)	MB 020421	Reporting Limit (RL)
4-BFB (surrogate standard)	93%	100±30%	1,2-Dichloropropane	<RL	0.5
Chlorodifluoromethane	<RL	0.5	Bromodichloromethane	<RL	0.5
Propene	<RL	1.0	1,4-Dioxane	<RL	1.0
Dichlorodifluoromethane	<RL	0.5	Trichloroethene (TCE)	<RL	0.5
Dimethyl Ether	<RL	0.5	2,2,4-Trimethylpentane	<RL	0.5
Chloromethane	<RL	1.0	Methyl Methacrylate	<RL	0.5
Dichlorotetrafluoroethane	<RL	0.5	Heptane	<RL	0.5
Vinyl Chloride	<RL	0.5	cis-1,3-Dichloropropene	<RL	0.5
Acetaldehyde	<RL	5.0	4-Methyl-2-pentanone (MiBK)	<RL	0.5
Methanol	<RL	5.0	trans-1,3-Dichloropropene	<RL	0.5
1,3-Butadiene	<RL	0.5	1,1,2-Trichloroethane	<RL	0.5
Bromomethane	<RL	0.5	Toluene	<RL	0.5
Chloroethane	<RL	0.5	2-Hexanone (MBK)	<RL	1.0
Dichlorofluoromethane	<RL	0.5	Dibromochloromethane	<RL	0.5
Ethanol	<RL	2.0	1,2-Dibromoethane	<RL	0.5
Vinyl Bromide	<RL	0.5	Tetrachloroethene (PCE)	<RL	0.5
Acrolein	<RL	1.0	Chlorobenzene	<RL	0.5
Acetone	<RL	2.0	Ethylbenzene	<RL	0.5
Trichlorofluoromethane	<RL	0.5	m & p-Xylene	<RL	1.0
2-Propanol (IPA)	<RL	2.0	Bromoform	<RL	0.5
Acrylonitrile	<RL	2.0	Styrene	<RL	0.5
1,1-Dichloroethene	<RL	0.5	1,1,2,2-Tetrachloroethane	<RL	0.5
Methylene Chloride (DCM)	<RL	1.0	o-Xylene	<RL	0.5
TertButanol (TBA)	<RL	0.5	1,2,3-Trichloropropane	<RL	0.5
Allyl Chloride	<RL	1.0	Isopropylbenzene (Cumene)	<RL	0.5
Carbon Disulfide	<RL	2.0	α-Pinene	<RL	0.5
Trichlorotrifluoroethane	<RL	0.5	2-Chlorotoluene	<RL	0.5
trans-1,2-Dichloroethene	<RL	0.5	n-Propylbenzene	<RL	0.5
1,1-Dichloroethane	<RL	0.5	4-Ethyltoluene	<RL	0.5
Methyl Tert Butyl Ether (MTBE)	<RL	0.5	1,3,5-Trimethylbenzene	<RL	0.5
Vinyl Acetate	<RL	1.0	β-Pinene	<RL	0.5
2-Butanone (MEK)	<RL	1.0	1,2,4-Trimethylbenzene	<RL	0.5
cis-1,2-Dichloroethene	<RL	0.5	Benzyl Chloride (a-Chlorotoluene)	<RL	0.5
Hexane	<RL	0.5	1,3-Dichlorobenzene	<RL	0.5
Chloroform	<RL	0.5	1,4-Dichlorobenzene	<RL	0.5
Ethyl Acetate	<RL	0.5	Sec-ButylBenzene	<RL	0.5
Tetrahydrofuran	<RL	0.5	1,2-Dichlorobenzene	<RL	0.5
1,2-Dichloroethane	<RL	0.5	n-ButylBenzene	<RL	1.0
1,1,1-Trichloroethane	<RL	0.5	1,2-Dibromo-3-Chloropropane	<RL	0.5
Benzene	<RL	0.5	1,2,4-Trichlorobenzene	<RL	0.5
Carbon Tetrachloride	<RL	0.5	Naphthalene	<RL	1.0
Cyclohexane	<RL	0.5	Hexachlorobutadiene	<RL	0.5





Atmospheric Analysis & Consulting, Inc.

QUALITY CONTROL / QUALITY ASSURANCE REPORT

ANALYSIS DATE : 02/04/2021

MATRIX : Air

UNITS : PPB (v/v)

INSTRUMENT ID : GC/MS-03

ANALYST : MB/RC

DILUTION FACTOR¹ : x33.08

VOLATILE ORGANIC COMPOUNDS BY EPA METHOD TO-15

Duplicate Analysis of AAC Sample ID: 210167-16351

Analyte Compounds	Sample	Duplicate	RPD ²
4-BFB (surrogate standard)	9.08	9.10	0.2
Chlorodifluoromethane	<SRL	<SRL	NA
Propene	711.00	789.00	10.4
Dichlorodifluoromethane	<SRL	<SRL	NA
Dimethyl Ether	<SRL	<SRL	NA
Chloromethane	<SRL	<SRL	NA
Dichlorotetrafluoroethane	<SRL	<SRL	NA
Vinyl Chloride	<SRL	<SRL	NA
Acetaldehyde	<SRL	<SRL	NA
Methanol	<SRL	<SRL	NA
1,3-Butadiene	<SRL	<SRL	NA
Bromomethane	<SRL	<SRL	NA
Chloroethane	<SRL	<SRL	NA
Dichlorofluoromethane	<SRL	<SRL	NA
Ethanol	<SRL	<SRL	NA
Vinyl Bromide	<SRL	<SRL	NA
Acrolein	<SRL	<SRL	NA
Acetone	1100.00	1210.00	9.5
Trichlorofluoromethane	<SRL	<SRL	NA
2-Propanol (IPA)	<SRL	<SRL	NA
Acrylonitrile	<SRL	<SRL	NA
1,1-Dichloroethene	<SRL	<SRL	NA
Methylene Chloride (DCM)	<SRL	<SRL	NA
TertButanol (TBA)	<SRL	<SRL	NA
Allyl Chloride	<SRL	<SRL	NA
Carbon Disulfide	<SRL	<SRL	NA
Trichlorotrifluoroethane	<SRL	<SRL	NA
trans-1,2-Dichloroethene	<SRL	<SRL	NA
1,1-Dichloroethane	<SRL	<SRL	NA
Methyl Tert Butyl Ether (MTBE)	<SRL	<SRL	NA
Vinyl Acetate	<SRL	<SRL	NA
2-Butanone (MEK)	<SRL	<SRL	NA
cis-1,2-Dichloroethene	<SRL	<SRL	NA
Hexane	<SRL	<SRL	NA
Chloroform	<SRL	<SRL	NA
Ethyl Acetate	<SRL	<SRL	NA
Tetrahydrofuran	<SRL	<SRL	NA
1,2-Dichloroethane	<SRL	<SRL	NA
1,1,1-Trichloroethane	<SRL	<SRL	NA
Benzene	<SRL	<SRL	NA
Carbon Tetrachloride	<SRL	<SRL	NA
Cyclohexane	<SRL	<SRL	NA

Analyte Compounds (Continued)	Sample	Duplicate	RPD ²
1,2-Dichloropropane	<SRL	<SRL	NA
Bromodichloromethane	<SRL	<SRL	NA
1,4-Dioxane	<SRL	<SRL	NA
Trichloroethene (TCE)	<SRL	<SRL	NA
2,2,4-Trimethylpentane	<SRL	<SRL	NA
Methyl Methacrylate	<SRL	<SRL	NA
Heptane	<SRL	<SRL	NA
cis-1,3-Dichloropropene	<SRL	<SRL	NA
4-Methyl-2-pentanone (MiBK)	<SRL	<SRL	NA
trans-1,3-Dichloropropene	<SRL	<SRL	NA
1,1,2-Trichloroethane	<SRL	<SRL	NA
Toluene	<SRL	<SRL	NA
2-Hexanone (MBK)	<SRL	<SRL	NA
Dibromochloromethane	<SRL	<SRL	NA
1,2-Dibromoethane	<SRL	<SRL	NA
Tetrachloroethene (PCE)	<SRL	<SRL	NA
Chlorobenzene	<SRL	<SRL	NA
Ethylbenzene	<SRL	<SRL	NA
m & p-Xylene	<SRL	<SRL	NA
Bromoform	<SRL	<SRL	NA
Styrene	<SRL	<SRL	NA
1,1,2,2-Tetrachloroethane	<SRL	<SRL	NA
o-Xylene	<SRL	<SRL	NA
1,2,3-Trichloropropane	<SRL	<SRL	NA
Isopropylbenzene (Cumene)	<SRL	<SRL	NA
α-Pinene	<SRL	<SRL	NA
2-Chlorotoluene	<SRL	<SRL	NA
n-Propylbenzene	<SRL	<SRL	NA
4-Ethyltoluene	<SRL	<SRL	NA
1,3,5-Trimethylbenzene	<SRL	<SRL	NA
β-Pinene	<SRL	<SRL	NA
1,2,4-Trimethylbenzene	<SRL	<SRL	NA
Benzyl Chloride (α-Chlorotoluene)	<SRL	<SRL	NA
1,3-Dichlorobenzene	<SRL	<SRL	NA
1,4-Dichlorobenzene	<SRL	<SRL	NA
Sec-ButylBenzene	<SRL	<SRL	NA
1,2-Dichlorobenzene	<SRL	<SRL	NA
n-ButylBenzene	<SRL	<SRL	NA
1,2-Dibromo-3-Chloropropane	<SRL	<SRL	NA
1,2,4-Trichlorobenzene	<SRL	<SRL	NA
Naphthalene	<SRL	<SRL	NA
Hexachlorobutadiene	<SRL	<SRL	NA

¹ Dilution factor is the product of the Canister Dilution Factor and the Analysis Dilution Factor.² Relative Percent Difference (RPD) between Sample analysis and Duplicate analysis (acceptable range is <25%).

SRL - Sample Reporting Limit (minimum)



CHAIN OF CUSTODY

210157

Antioch Location

2825 Verne Roberts Circle
Antioch, CA 94509

Phone (925) 680-4300 | Fax (925) 680-4416

Lab info:

Eric Grosjean at AA&C
1534 Eastman AVE. Suite A
Ventura, CA 93003

Client / Project: Bloom	Project / Sample Location: Main	Test / Analytical Method: SC 25.3, TO-12, & TO-15
Project No.: 005AS-006509	Purchase Order No:	Special Analysis / Reporting Instructions:
Send Analytical Report To: Antioch QA/QC: AntiochQA-QC@montrose-env.com F. Schall	Sampler or PM Signature:	

Run / Sample No.	Date	Time	Containers	Sample Fraction	Reagent	Lab / Sample ID No.
BGLF-25.3-1a	1/26/21	1500	2	Summa Cannister/ Vial	--	16289
BGLF-25.3-1b	1/26/21	1500	2	"	--	16290
BGLF-25.3-2	1/26/21	1630	2	"	--	16291
BGLF-25.3-3	1/26/21	1730	2	"	--	16292
BGDI-25.3-1a	1/27/21	0930	2	"	--	16293
BGDI-25.3-1b	1/27/21	0930	2	"	--	16294
BGDI-25.3-2	1/27/21	1030	2	"	--	16295
BGDI-25.3-3	1/27/21		2	"		16296
NG-25.3-1a	1/27/21		2	"		16297
NG-25.3-1b	1/27/21		2	"		16298
NG-25.3-2	1/27/21		2	"		16299
NG-25.3-3	1/27/21		2	"		16300
NG-TO 12 & 15-1	1/27/21		1	Cannister		16301
NG-TO 12 & 15-2	1/27/21		1	"		16302
NG-TO 12 & 15-3	1/27/21		1	"		16303
Total Containers			27			

Relinquished by <i>Jaime Rios</i>	Date 1-28-21	Time 8:45	Received by <i>Samantha Donovan</i>	Date 1/28/21	Time 850	Temp.
Relinquished by <i>Samantha Donovan FedEx</i>	Date 1-28-21	Time 850	Received by <i>[Signature]</i>	Date 1/29/21	Time 1530	Temp.
Relinquished by	Date	Time	Received by	Date	Time	Temp.

Client returned returned 7x 25.3 sets (1x unused) + 7x 6L cans

28 of 30

W005AS-006509-RT-1458

Bloom Energy – ES-05 fired on Natural Gas
2021 Engineering Report

THIS IS THE LAST PAGE OF THIS DOCUMENT

If you have any questions, please contact one of the following individuals by email or phone.

Name: Mr. Finn Schall
Title: Project Manager
Region: West
Email: fschall@montrose-env.com
Phone: 913-530-4713

Name: Mr. Max Jakovleski
Title: District Manager
Region: West
Email: mjakovleski@montrose-env.com
Phone: 925-750-0326

APPENDIX D. SOFC SYSTEM TACT DOCUMENTATION

This section includes the following supporting documentation for the TACT analysis provided:

- ▶ State of California Air Resources Board; Distributed Generation Certification of Bloom Energy Corporation ES-5 Fuel Power Cell – Natural Gas; Executive Order DG-044; July 13, 2021.



Gavin Newsom, Governor
Jared Blumenfeld, CalEPA Secretary
Liane M. Randolph, Chair

July 13, 2021

Marisa Blackshire, Senior Director
Bloom Energy Corporation
Marisa.Blackshire@bloomenergy.com

Dear Ms. Blackshire:

California Air Resources Board staff has reviewed the Distributed Generation (DG) Recertification application, received January 15, 2021, for Bloom Energy's natural gas fueled, 300kW ES-5 Fuel Power Cell. Based on the information submitted, staff has determined that it meets the requirements of article 3, title 17, California Code of Regulations, sections 94200–94214 (DG Certification Program). We are pleased to provide you with the enclosed Executive Order DG-044 for the recertification of the ES-5 Fuel Power Cell.

If you have questions about the enclosed Executive Order or the DG Certification Program, please contact me at carey.bylin@arb.ca.gov or Jeb Boodry at jeb.boodry@arb.ca.gov.

Sincerely,

/s/

Carey Bylin, Manager
Industrial Strategies Division

Enclosure: Executive Order DG-044.pdf

cc: Jeb Boodry, Air Resources Engineer
Industrial Strategies Division

**State of California
AIR RESOURCES BOARD**

Executive Order DG-044

**Distributed Generation Certification of
Bloom Energy Corporation
ES-5 Fuel Power Cell – Natural Gas**

WHEREAS, the California Air Resources Board (CARB) was given the authority under California Health and Safety Code Section 41514.9 to establish a statewide Distributed Generation (DG) Certification Program to certify electrical generation technologies that are exempt from the permit requirements of air pollution control or air quality management districts;

WHEREAS, CARB adopted the DG Certification Regulation at California Code of Regulations (CCR), title 17, article 3, sections 94200 to 94214;

WHEREAS, this DG Certification does not constitute an air pollution permit or eliminate the responsibility of the end user to comply with all federal, state, and local laws, rules and regulations;

WHEREAS, on May 4, 2015, Bloom Energy Corporation applied for a DG Certification of its ES-5 Fuel Power Cell, referred to at that time as the ES-5 Fuel Cell Power Generation System, and whose application was deemed complete on October 8, 2015;

WHEREAS, Bloom Energy Corporation has demonstrated, according to test methods specified in CCR, title 17, section 94207, that its natural gas fueled ES-5 Fuel Power Cell has complied with the following DG Certification Regulation 2007 Fossil Fuel Emission Standards pursuant to CCR, title 17, section 94203(b):

1. Emissions of oxides of nitrogen no greater than 0.07 pounds per megawatt-hour;
2. Emissions of carbon monoxide no greater than 0.10 pounds per megawatt-hour; and,
3. Emissions of volatile organic compounds no greater than 0.02 pounds per megawatt-hour;

WHEREAS, Bloom Energy Corporation has demonstrated that its ES-5 Fuel Power Cell complies with the emission durability requirements in CCR, title 17, section 94203(d);

WHEREAS, Bloom Energy Corporation was issued a DG Certification on January 26, 2016, for its ES-5 Fuel Power Cell;

WHEREAS, Bloom Energy Corporation, on January 15, 2021, applied for a DG recertification of its ES-5 Fuel Power Cell, and CARB deemed the application complete on May 14, 2021;

WHEREAS, from August 11-13, 2020, Bloom Energy Corporation conducted a new source test of its ES-5 Fuel Power Cell due to improvements of the anode tail-gas oxidizer that were expected to improve carbon monoxide conversion and reduce emissions;

WHEREAS, I find that the Applicant, Bloom Energy Corporation, has met the requirements specified in CCR, title 17, article 3, and has satisfactorily demonstrated that the ES-5 Fuel Power Cell meets the DG Certification Regulation 2007 Fossil Fuel Emission Standards at CCR, title 17, section 94203(b);

NOW THEREFORE, IT IS HEREBY ORDERED, that a DG Certification, Executive Order DG-044, originally executed at Sacramento, California on January 26, 2016, is hereby renewed.

This DG Certification:

- 1) is subject to all conditions and requirements of CARB's DG Certification Program, CCR, title 17, article 3, including the provisions relating to inspection, denial, suspension, and revocation;
- 2) shall be void if any manufacturer's modification results in an increase in emissions or changes the efficiency or operating conditions of a model, such that the model no longer meets the DG Certification Regulation 2007 Fossil Fuel Emission Standards: and,
- 5) shall expire on the 27th day of March 2026.

Executed at Sacramento, California, this 13 day of July 2021.

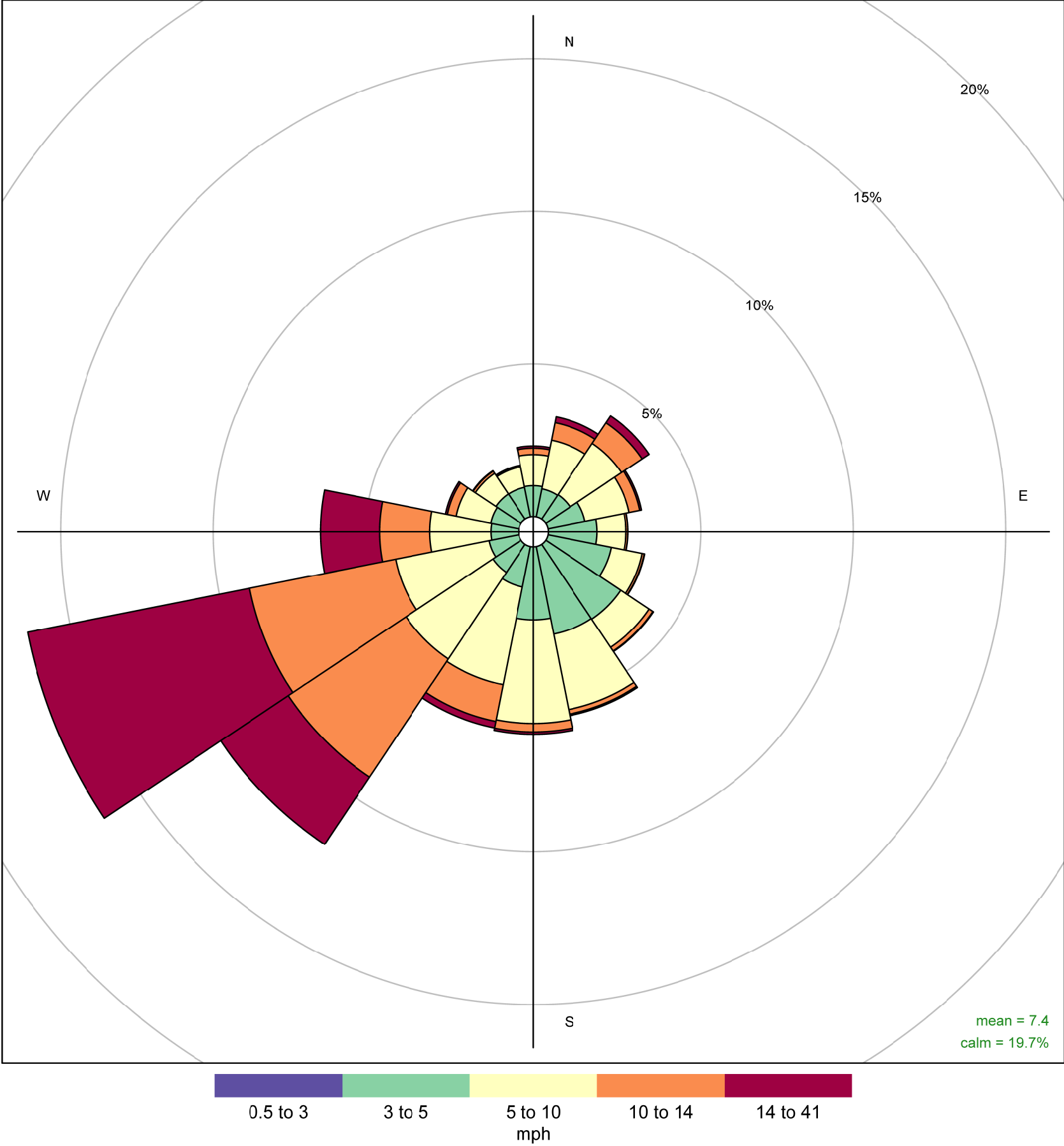


Matthew Botill
Acting Division Chief
Industrial Strategies Division

APPENDIX B

FIGURES AND DRAWINGS

Figure 1-1 Contains Confidential Business Information and has been Redacted.



**Figure 3-1
Wind Rose**

Amazon Data Services,
Boardman, Oregon

Key Map



Note
mph = miles per hour.

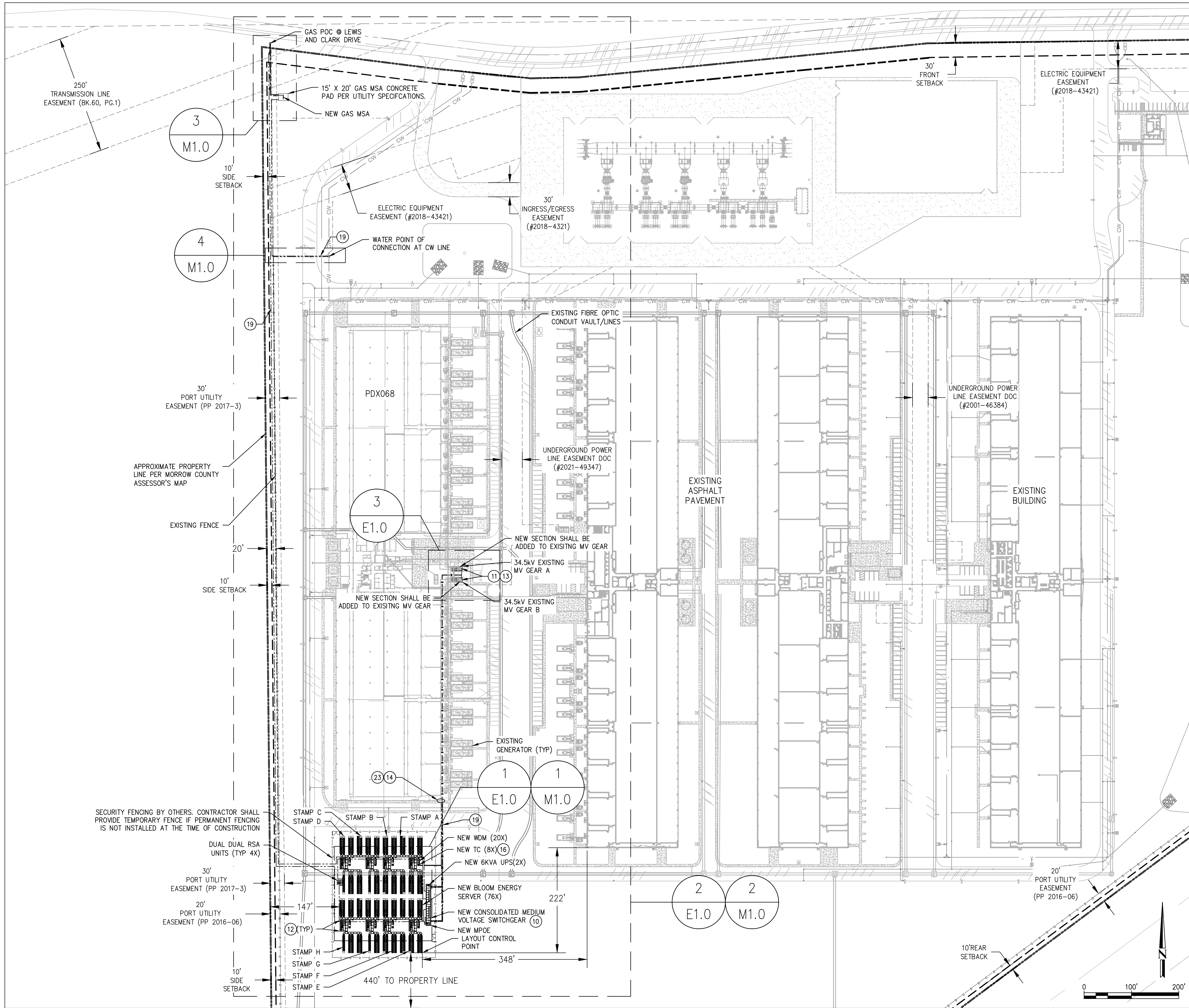


Data Source
Meteorological data for January 1, 2018 through December 31, 2022 were obtained from the KHRI station at the Hermiston Municipal Airport.



This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.
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Figure 3-3 Contains Confidential Business Information and has been Redacted.



SITE REFERENCE NOTE:
EXISTING SITE CONDITIONS TAKEN FROM ISSUE FOR PERMIT SET, PROJECT-75282 LEWIS AND CLARK DRIVE- BUILDING 4, DATED-03/25/2022. PLANS ARE BASED ON PREVIOUS CONSTRUCTION DOCUMENTS, AND DO NOT REPRESENT EXISTING CONDITIONS TO THE ACCURACY OF A SURVEY. CONTRACTOR SHALL FIELD VERIFY ALL ELEVATIONS, UTILITIES, ETC., TO ENSURE THE INTENDED DESIGN IS ACHIEVABLE, AND NOTIFY THE OWNER IF ANY CONFLICTS OR DISCREPANCIES ARISE. THE CONTRACTOR SHALL CONFIRM IN WRITING WITH THE CONSTRUCTION MANAGER AT TIME OF CONSTRUCTION THAT THEY HAVE THE MOST CURRENT VERSION OF CONSTRUCTION DOCUMENTS AND SURVEY RELATED INFORMATION NECESSARY TO CONSTRUCT THE PROJECT.

OVERALL SITE PLAN
SCALE: 1" = 100'

1
G1.1

GENERAL NOTES

1. CLEAN AND PRIME ALL NEW WALL MOUNTED PIPING AND CONDUIT. PIPING AND CONDUIT SHALL BE PAINTED WITH EXTERIOR GRADE PAINT TO MATCH EXISTING.
2. CONDUITS AND PIPES MOUNTED TO BUILDING WALL SHALL BE SUPPORTED AS PER LOCAL CODE, RUN AT HEIGHT ABOVE DOORWAYS, AND STAND OFF WALL TO AVOID EXISTING CONDUITS AND PIPES.
3. SEE BLOOM ENERGY PRODUCT INSTALLATION DRAWINGS FOR UTILITY CONNECTIONS TO ANCILLARY EQUIPMENT AND ENERGY SERVER.
4. ALL PULL BOXES AND VAULTS REQUIRED ARE NOT SHOWN. CONTRACTOR SHALL PROVIDE PULL BOX OR VAULT FOR CONDUIT RUNS WITH MORE THAN 360-DEG BENDS OR OTHERWISE REQUIRED PER CABLE PULLING TENSION OR SIDEWALL PRESSURE LIMITATIONS. CONTRACTOR SHALL SIZE PULL BOX OR VAULT IN COMPLIANCE WITH NEC REQUIREMENTS.

REFERENCE SHEET NOTES

10. NEW BLOOM ENERGY FURNISHED, CONTRACTOR INSTALLED, DISCONNECT SWITCH. MOUNT PER MANUFACTURER AND UTILITY SPECIFICATIONS.
11. CONTRACTOR SHALL TERMINATE ELECTRIC FEEDER AS SHOWN. REFER TO ELECTRICAL SINGLE LINE DIAGRAM FOR ADDITIONAL REQUIREMENTS.
12. CONTRACTOR SHALL PROVIDE TWO GROUNDING RODS TO BE PLACED 6' APART MINIMUM. REFER TO ELECTRICAL SINGLE LINE DIAGRAM FOR ADDITIONAL REQUIREMENTS.
13. NEW ELECTRICAL FEEDER SHALL BE FURNISHED AND INSTALLED BY THE CONTRACTOR. REFER TO ELECTRICAL SINGLE LINE DIAGRAM FOR ADDITIONAL REQUIREMENTS.
14. MOUNT NEW CONDUIT / PIPE TO EXTERIOR WALL AND ALONG EXISTING CABLE TRAY SUPPORT STRUCTURE ADJACENT TO THE BUILDING. COORDINATE EXACT ROUTING WITH CUSTOMER REPRESENTATIVE IN THE FIELD.
16. FACTORY WIRED BLOOM ENERGY SERVER EMERGENCY POWER-OFF SWITCH (EPO) SHALL BE LOCATED ON THE FRONT OF EACH TELEMETRY CABINET.
19. CONTRACTOR SHALL PROVIDE TRENCH FOR UNDERGROUND UTILITIES IN THIS LOCATION AND HAND DIG TRENCHES WHERE THEY CROSS EXISTING UTILITIES. REFER TO UNDERGROUND/TRENCH CONDUIT AND PIPING DETAIL FOR ADDITIONAL REQUIREMENTS.
23. CONTRACTOR SHALL TRANSITION ALL ABOVEGROUND NEW LINES TO UNDERGROUND TOWARD ANCILLARY EQUIPMENT. ABOVE GROUND UTILITIES SHALL BE PROTECTED AS NECESSARY, THEN ROUTED UNDERGROUND TO EQUIPMENT STUB-UP LOCATIONS PER MECHANICAL DETAIL.

EXISTING UTILITY NOTE:
THE LOCATION OF EXISTING UTILITIES IS SHOWN FOR THE CONTRACTOR'S REFERENCE. EXACT LOCATION, DEPTH AND SIZE OF ALL EXISTING UTILITIES IS NOT KNOWN. CONTRACTOR SHALL ASSUME RESPONSIBILITY FOR ALL EXISTING UTILITIES NOT SHOWN ON THESE DRAWINGS. CONTRACTOR TO FIELD VERIFY LOCATION OF EXISTING UNDERGROUND UTILITIES AND PROTECT THE EXISTING UNDERGROUND UTILITY LINES FROM DAMAGE WHEN CROSSING WITH NEW UNDERGROUND UTILITIES. THE CONTRACTOR SHALL BE RESPONSIBLE FOR REPAIR OR REPLACEMENT OF ANY DAMAGED LINES. THE CONTRACTOR SHALL NOTIFY THE ENGINEER IMMEDIATELY IF ANY FIELD CONDITIONS ENCOUNTERED DIFFER FROM THOSE REPRESENTED HEREON. SUCH CONDITIONS COULD RENDER THE DESIGNS HEREON INAPPROPRIATE AND MAY REQUIRE ADJUSTMENTS TO AVOID CONFLICTS.

NOTE :
ON-SITE PARKING NOT IMPACTED BY SERVER INSTALLATION.

Bloomenergy

4353 N. FIRST STREET
SAN JOSE, CA 95134
PROPRIETARY AND CONFIDENTIAL
BLOOM ENERGY CORPORATION ALL RIGHTS RESERVED. THIS DOCUMENT IS FOR REFERENCE ONLY AND MAY NOT BE USED WITHOUT THE WRITTEN PERMISSION OF BLOOM ENERGY. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT PERMISSION OF BLOOM ENERGY IS PROHIBITED.



520 SOUTH MAIN STREET, SUITE 2531
AKRON, OH 44311
t: (330) 572-2100 Fax: (330) 572-2102
GPD PROJECT # 2020345.27

ENGINEER OF RECORD
LEONARDO A. SFERRA
LICENSE #92464PE



CUSTOMER SITE
AMAZON WEB SERVICE
PDX062.Z
75282 LEWIS AND CLARK DR.
BOARDMAN, OR 97818



REVISION HISTORY		
REV	REVISION ISSUE	DATE
-	INITIAL RELEASE	03/13/2023

DESIGNED BY	REVIEWED BY
DRAWN BY LATHASHREE	APPROVED BY

SHEET TITLE	
OVERALL SITE PLAN	
DRAWING NUMBER	
G1.1	
BLOOM ENERGY DOCUMENT	
DOC-1015081	
THIS DRAWING IS 24" X 36" AT FULL SIZE	
SITE ID: PDX062.Z	SHEET 03 OF 33

AMAZON CONFIDENTIAL

APPENDIX C

CORRESPONDENCE FROM CASCADE NATURAL GAS
CORPORATION

Marisa Blackshire

From: Marisa Blackshire
Sent: Monday, April 24, 2023 9:51 AM
To: Marisa Blackshire
Subject: FW: Followup from Early Aug Mtg

From: Marek, Chanda <Chanda.Marek@cngc.com>
Sent: Wednesday, August 24, 2022 10:51 AM
To: Marisa Blackshire <Marisa.Blackshire@bloomenergy.com>; Krebsbach, Abbie <Abbie.Krebsbach@mdu.com>; Amanda Marruffo <Amanda.Marruffo@bloomenergy.com>
Cc: Cunningham, Brian <Brian.Cunnington@cngc.com>
Subject: RE: Followup from Early Aug Mtg

EXTERNAL EMAIL

The draft contract we provided to Bloom has the following statement:

The service provided herein is contingent upon the ODEQ determination that the natural gas delivered hereunder is exempt from the requirements of the CPP under one or more exemption provisions and that Cascade's reported emissions from combustion and/or non-combustion related processing of natural gas delivered to Bloom are exempt from Cascade's CPP compliance obligation.

APPENDIX D

AMAZON DATA SERVICES SUPPORT LETTER



February 14, 2023

Mr. Mike Shepherd
Bloom Energy

Re: PDX Fuel Cell Projects

Dear Mr. Shepherd,

Amazon Data Services, Inc. (ADS) supports Bloom Energy's efforts to seek a favorable determination from the Oregon Department of Environmental Quality (ODEQ) that the fuel cell projects in the Boardman area represent the best available emissions reduction (BAER) technology. ADS is investing in fuel cells as a new, innovative technology that can provide highly available, resilient infrastructure while also providing a pathway for less carbon intensive solutions in the region. ADS intends to use the fuel cells as an interim power supply solution to support our operations while we continue to await the completion of transmission and distribution upgrades and system reliability improvements to the region. Without the fuel cells, we would not have access to sufficient incremental power to serve our customers and we see this solution as one way to bridge the gaps that arise due to the regional challenges that impede the realization of new transmission infrastructure and our ability to enable new renewable generation in the region. According to the Bonneville Power Administration¹, the Boardman area is at the limit of the existing 230 kV sources and there are over 2,500 megawatts of renewable energy generation in the queue waiting to come online.

ADS is committed to approaching sustainability with bold thinking and relentless innovation. In furtherance of this commitment, ADS has elected to use Bloom's fuel cell technology to support a small portion of ADS operations in the area because it is better than other available alternatives that would result in a higher end-to-end emissions footprint. Bloom's fuel cells operate at some of the highest electrical efficiencies of any gas-based power generation device and need less fuel to generate the same amount of power as a combustion alternative, driving a lower emissions profile. This is further highlighted by the certification of Bloom's energy servers by the California Air Resources Board (CARB) as meeting the distributed generation standards. Thank you for your continued support as we work to move these projects forward.

DocuSigned by:

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Nat Sahlstrom

Vice President, Amazon Data Services, Inc.

Authorized Signatory

¹ <https://www.bpa.gov/-/media/Aep/finance/asset-management/public-materials-project-synopsis/longhorn-substation.pdf>



APPENDIX E

MARKET DEMAND SEARCH LETTER

Bloom Energy Corporation

4353 North First Street
San Jose, CA 95134
www.bloomenergy.com



February 2, 2023

Ms. Leslie Riley

Project Air Quality Consultant
Maul Foster Alongi
6 Centerpoint Drive
Suite 360
Lake Oswego, OR 97035

Dear Ms. Riley:

You requested that I prepare for you a summary of the efforts that Bloom Energy (Bloom) has made to identify a potential offtaker of CO₂ generated by our fuel cell installations planned for use at Amazon Data Services (ADS) sites in the Boardman, OR area.

Bloom has invested considerable effort trying to identify any potential customers for CO₂ generated by the Bloom fuel cells without success. As you are aware, ADS is seeking to install Bloom fuel cells in order to address a shortfall in the amount of electricity that Umatilla Electric Cooperative is able to provide prior to completion of the Boardman to Hemingway transmission line and the related equipment needed to serve ADS's full load. Completion of those system upgrades is projected for sometime in the 2029-2030 period. If completed in a timely fashion, the Bloom fuel cells are expected to cease providing baseload power in approximately 6 years. I bring this up because the short time period over which the Bloom fuel cells would provide CO₂ affects the options available. With that background, let me summarize our analysis and efforts to date to find a use for CO₂ generated from the fuel cells.

A typical use of industrial CO₂ in other parts of the country is for enhanced oil recovery. As Oregon has no oil and gas exploration/extraction, there is no local customer. Trucking CO₂ to states/regions with such activity (e.g., California, Texas), is cost-prohibitive and the CO₂ generated by the trucks needed to transport the CO₂ would be considerable. Furthermore, in enhanced oil recovery, there is little certainty that the CO₂ injected into the wells remains permanently in the ground. In Washington state, for example, to qualify as permanent sequestration, there must be a high level of confidence that 99 percent of the CO₂ will remain in the ground for at least 1,000 years. See, WAC 173-407-110, definition of "permanent sequestration." Enhanced oil recovery does not typically meet this standard and so was eliminated as an option.

Ms. Leslie Riley
Februrary 2, 2023

Some parts of the country have developed bespoke CO₂ storage projects where the gas (or supercritical CO₂) is injected into subterranean chambers where it is permanently sequestered. I understand that Oregon law currently does not allow for such subterranean sequestration and, anyway, such a project could not be permitted, built and brought online in time to serve the short-term need of the Bloom fuel cells. Therefore, a site-specific sequestration project was not considered a feasible option.

Bloom explored other alternatives, such as concrete injection and industrial gas customers. There are no existing markets that we were able to identify that would be able to take a material amount of the approximately 90,000 tons of CO₂ that a single installation would generate. All existing CO₂ consumers have established suppliers and were not willing to consider changing supplier where the Bloom fuel cells will only be capable of providing CO₂ for a few years. In addition, and perhaps most importantly, the existing consumers of CO₂ are all too distant from the Boardman area for transportation by truck to make economic or environmental sense.

Finally, Bloom investigated whether any new user of CO₂ might be willing to site a facility near the fuel cell locations. Again, due to the short life of the Bloom fuel cells, there was no interest. This makes sense as it is the rare operation that has such a high return on investment that it can financially justify a facility whose feedstock would disappear after approximately 6 years. We were told that the supply would have to be stable for a minimum of 20 years before any developer would begin to entertain the notion of constructing a facility.

Bloom is very interested in the possibility of the CO₂ generated from its fuel cells being able to be captured and either permanently sequestered or reused in a commercially feasible and environmentally responsible manner. However, due to their remote location and short lifespan, the Oregon fuel cells intended for the ADS sites do not present a viable case for CO₂ sequestration or reuse. Please let me know if you have any questions after reviewing this letter.

Very truly yours,

DocuSigned by:

Mike Shepherd

59D7D244F9CC4FA...

Mike Shepherd

Enterprise Account Executive

cc: Marisa Blackshire
Tom Wood

APPENDIX F

RNG TERM SHEETS

Appendix F Contains Confidential Business Information and has been Redacted.

APPENDIX G

COST EFFECTIVENESS TABLE

Table 1
Cost Effectiveness Derivation for BAER Installations
Amazon Data Services—Boardman, Oregon

Process Unit ID	Emissions Unit Description	GHG Annual ⁽¹⁾ Emissions Estimate (tons/yr)	GHG Reduced by Process Unit ^(a) (tons/yr)
SOFC	SOFC	88,660	84,482
SOFCRT	SOFC plus Rooftop Solar	84,281	88,861
SOFCATT	SOFC plus RNG Attributes	54,969	118,173

Process Unit ID	Emissions Unit Description	SOFC Capital Investment ⁽¹⁾ (\$)	Solar Capital Investment (\$)	Total Capital Investment (\$)	Capital Recovery Cost ^(c) (\$)	Direct Annual Costs			Total Indirect Annual Costs ^(g) (\$/yr)	Total Annual Cost ^(h) (\$/yr)	Annual Cost Effectiveness ⁽ⁱ⁾ (\$/ton GHG)
						SOFC Service Costs ⁽¹⁾ (\$/yr)	Fuel (\$/yr)	Total Direct Annual Costs (\$/yr)			
SOFC	SOFC	110,705,267	--	110,705,267	10,301,189	3,110,400	9,921,795 ^(e)	13,032,195	16,595,639	29,627,834	351
SOFCRT	SOFC plus Rooftop Solar	110,705,267	17,000,000 ⁽³⁾	127,705,267	15,378,327	3,110,400	9,763,046 ^(e)	12,873,446	22,352,778	35,226,224	396
SOFCATT	SOFC plus RNG Attributes	110,705,267	--	110,705,267	10,301,189	3,110,400	25,522,260 ^(f)	28,632,660	16,595,639	45,228,299	383

See notes and formulas on following page.

Table 1 (Continued)
Cost Effectiveness Derivation for BAER Installations
Amazon Data Services—Boardman, Oregon

NOTES:

(a) Pollutant avoided by device (tons/yr) = (eGRID GHG annual emissions estimate [tons/yr]) - (GHG annual emissions estimate [tons/yr])		
eGRID annual emissions estimate (tons/yr) =	173,142	(b)
(b) eGRID GHG annual emissions estimate (tons/yr) = (eGRID emission factor [lb CO ₂ /MWh]) x (energy requirement [MWh]) x (ton/2,000 lb)		
eGrid emission factor (lb CO ₂ /MWh) =	1,627	(2)
Annual energy requirement (MWh) =	212,868	(3)
(c) Capital recovery cost (\$) = (total capital investment [\$]) x (technology capital recovery factor); see reference (6)		
SOFC capital recovery factor =	0.0931	(d)
Solar capital recovery factor =	0.1204	(d)
(d) Capital recovery factor = (interest rate [%] / 100) x (1 + [interest rate [%] / 100] ^ [economic life {yrs}]) / ([1 + [interest rate [%] / 100] ^ [economic life {yrs}] - 1]; see reference (7).		
Interest rate (%) =	8.5	(8)
Rooftop solar economic life (yr) =	15	(9)
SOFC economic life (yr) =	30	(1)
(e) Fuel cost (\$/yr) = (fuel requirements [MMBtu/day]) x (annual days of operation [days/yr]) x (cost of fuel [\$/MMBtu])		
SOFC natural gas requirements (MMBtu/day) =	4,100	(1)
SOFC plus rooftop solar natural gas requirements (MMBtu/day) =	4,034	(1)
Annual days of operation (days/yr) =	365	(1)
Average cost of natural gas in Boardman, OR (\$/MMBtu) =	6.63	(1)
(f) Fuel cost (\$/yr) = (natural gas requirements [MMBtu/hr]) x (annual hours of operation [hrs/yr]) x (cost of natural gas [\$/MMBtu]) + (RNG requirements [MMBtu/hr]) x (annual hours of operation [hrs/yr]) x (cost of RNG attributes [\$/MMBtu])		
SOFC plus RNG attributes natural gas requirements (MMBtu/day) =	4,100	(1)
SOFC plus RNG attributes RNG requirements (MMBtu/day) =	1,583	(1)
Annual days of operation (days/yr) =	365	(1)
Average cost of natural gas in Boardman, OR (\$/MMBtu) =	6.63	(1)
Cost of RNG attributes (\$/MMBtu) =	27.0	(1)
(g) Total indirect annual cost (\$) = (0.60) x ([SOFC service cost {\$}] + [solar fixed operation and maintenance cost {\$}]) + (0.04) x (total capital investment [\$]) + (capital recovery cost [\$]); see reference (10).		
(h) Total annual cost (\$) = (total direct annual cost [\$]) + (total indirect annual cost [\$])		
(i) Annual cost effectiveness (\$/ton) = (total annual cost [\$]) / (pollutant removed by control device [tons/yr])		

REFERENCES:

- (1) Information provided by Bloom Energy.
- (2) US EPA, January 2023, "eGRID Summary Tables 2021." Value for NW Region.
- (3) Information provided by ADS
- (4) National Renewable Energy Laboratory, Annual Technology Baseline, 2023. Value represents the 2022 capital cost of battery storage for an 8-hr battery.
- (5) Value represents number of units required for 7 days of storage based on 8 hour batteries.
- (6) US EPA Air Pollution Control Cost Manual, Section 1, Chapter 2 "Cost Estimation: Concepts and Methodology" issued on February 1, 2018. See equation 2.8.
- (7) US EPA Air Pollution Control Cost Manual, Section 1, Chapter 2 "Cost Estimation: Concepts and Methodology" issued on February 1, 2018. See equation 2.8a.
- (8) Federal Reserve bank prime loan rate, August, 2023.
- (9) National Renewable Energy Laboratory, Annual Technology Baseline, 2023.
- (10) US EPA Air Pollution Control Cost Manual, Section 6, Chapter 1 issued December 1998. See section 1.5.