BEST AVAILABLE EMISSIONS REDUCTION ASSESSMENT

BLOOM ENERGY

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

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CONTENTS

TABLES AND ILLUSTRATIONS

ACRONYMS AND ABBREVIATIONS

ADS	Amazon Data Services, Inc.
BAER	Best Available Emissions Reduction
B2H	Boardman to Hemingway
BPA	Bonneville Power Administration
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CPP	Climate Protection Program
CRF	capital recovery factor
CSP	concentrated solar power
EFSC	Oregon Energy Facility Siting Council
EPA	U.S. Environmental Protection Agency
GHG	greenhouse gas
HAP	hazardous air pollutant
lb	pound(s)
MT	metric tons
MW	megawatt
MWh	megawatt-hour
MMBtu	million British thermal units
MMscf	million standard cubic feet
OAR	Oregon Administrative Rule
PDX109	ADS facility located at 75242 Gar Swanson Road, Boardman, Oregon
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 PDX109 data center located in Boardman, Oregon (PDX109 or "site") under Standard Air Contaminant Discharge Permit (ACDP) No. 25-0062-ST-01 issued August 27, 2021. PDX109 is considered a synthetic minor source under the Title V program.

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). The site houses cloud computer systems and associated components such as telecommunications and data storage systems. Equipment includes security systems, data communications equipment, environmental controls, and diesel-fired backup emergency generators. The PDX109 site air permit currently authorizes ADS to operate 112 emergency generators, for a total capacity of approximately 266 megawatts (MW).

In order to operate the site, ADS requires a minimum continuous electrical supply. ADS works closely with local and regional utilities to secure this supply and despite these efforts ADS is currently limited to 40 MW of electricity at PDX109, which is less than nameplate capacity at the site. The current timeline for when the nameplate capacity of this site can be served by the local utilities is several years away. The additional 24 MW provided by onsite fuel cell generation is proposed to supplement this shortfall while various transmission infrastructure improvements in the region are advanced. The proposed fuel cell generation will only meet a small portion of ADS' customer needs at this location. An example of the type of system wide upgrade in the region and that will provide additional load serving capacity that might support the type of constraint at PDX109 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. As a result, it is not anticipated that construction on the B2H Transmission Line will begin until approximately 2026, with construction completion estimated to take approximately four years absent delays or extensions. This is an example of the type of project that is needed in the region and the timelines that are associated with their completion; completion of the B2H Transmission Line in and of itself will not necessarily fully address regional infrastructure needs. Without on-site power generation, PDX109 cannot efficiently utilize existing equipment and meet ADS customer needs. On-site power generation is necessary to maintain the operations authorized by the existing permit and is not intended to supply energy to new equipment or to reduce the amount of electricity currently supplied by the Umatilla Electric Cooperative (UEC). Limitations that affect the selection of an on-site power generation solution include the following:

- The site requires a supply of power generation on site to address the energy gap that currently exists.

- The site requires 100 percent uptime.
- 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 102 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 additional natural gas to the site for use in a combustion or oxidation process.

The following Best Available Emission Reduction (BAER) analysis has been conducted with the understanding that any potential power supply solution located at PDX109 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. In addition, emissions generated from the use of natural gas delivered directly to the site by other than a local distribution company would be "covered emissions" attributable to that covered entity under the CPP.

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]). PDX109 is an existing source with anthropogenic GHG process emissions from the oxidation of natural gas that exceed 25,000 MT CO_2e per year. The natural gas employed at PDX109 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 DEQ's request that BAER be addressed as part of the permitting process consistent with OAR 340-271-0310(1)(a).

This BAER analysis evaluates technically achievable 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 to the site are completed.

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 CO_2e, 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 subsection (c):

   a. An estimate of annual average covered emissions reductions achieved if the strategy were implemented compared to the emissions estimated in paragraph (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 or 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 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 were considered:

- Additional on-site energy conservation
- Local power grid
- Solar energy
- Wind energy
- Bloom Energy solid oxide fuel cell (SOFC) technology
- Bloom Energy SOFC and carbon dioxide (CO_2) 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 PDX109 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 BPA, the Boardman area is at the limit of the existing 230 kV 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' need to conserve. In short, economic prudence and lack of resource, as well as ADS' 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 measuring, tracking, and reporting 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 utilizes Power Usage Effectiveness as the industry-preferred metric for measuring energy efficiency in data centers, for both guiding new facility design and monitoring existing facility operations. Consistent Power Usage Effectiveness 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[1], 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. This means that migrating the average 1-megawatt enterprise data center with 30 percent utilization to AWS, a customer could reduce their carbon emissions by 400 to 1000 metric tons per year. In addition to the efficiency of internal operations, Amazon leads the Amazon Sustainability Data Initiative (Amazon.com, Inc.) seeking to accelerate sustainability research and innovation by minimizing the cost and time required to acquire and analyze large sustainability datasets. This helps researchers, scientists, and innovators around the world advance their work on sustainability-related research and provides publicly available, free access to important scientific data that can otherwise be hard for researchers to access or analyze.

As a result, all reasonable energy conservation measures have been employed, including measures such as energy efficient lighting. The facility houses computer systems and associated components, such as telecommunications and data storage systems. This equipment is intrinsic to the product that ADS produces, i.e., the storage, management and dissemination of electronic data. No additional change in equipment is possible without impacting the quality of ADS' product. Therefore, additional on-site energy conservation is eliminated as technically infeasible.

[1] https://www.aboutamazon.com/news/sustainability/reducing-carbon-by-moving-to-aws

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 a smaller contribution 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 PDX109. The UEC is currently unable to deliver more than 40 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. Until that day arrives, on-site generation is one solution to support the shortfall. A letter outlining the energy shortfall for ADS' data centers and their support for a sustainable interim power supply is included in Appendix A.

Therefore, the local power grid is currently technically incapable of meeting the need for the approximately 24 MW of power generation to PDX109 that is under consideration in this BAER analysis. For that reason, supply of the needed electricity 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° 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 thus 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 PDX109 site. As noted at the outset of this analysis, virtually all of the usable portions of the site are dedicated to equipment critical to the site's intended purpose and cannot be repurposed to solar power generation.

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 in order 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. 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.

Additionally, 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. Therefore, construction of a solar farm is not a viable option. It will not be commercially available within the time frame needed.

3.2.3.4 Rooftop Solar

ADS has a goal to power all its operations with 100 percent renewable energy and is currently in the process of evaluating a number of different rooftop solar technologies that can be deployed at their existing and planned facilities. Some of the initial evaluations of available technology would produce less than 1 average megawatt per year per data center. This is a fraction of the energy needs for a data center facility and subject to significant variability in output due to cloud cover and no output during nighttime periods. In addition, many of ADS' facilities were not constructed with the expectation for a rooftop PV facility and would need significant modifications to accept the additional weight such a facility would represent. ADS is continuing to evaluate this as a resource for inclusion at their facilities, but it is not a feasible technology at this time.

Off-site solar electricity generation is also not a viable option for the site. As noted above, 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. Solar 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 those of a more reliable source of energy. Therefore, solar energy is considered technically infeasible for providing approximately 24 MW of power generation to the PDX109 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.

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.

Another challenge is that the 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. 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 sited for optimal wind conditions, but this could be several miles from the site. During periods of low energy generation PDX109 would not have sufficient power, putting operations at risk.

Similar to solar energy, planning, permitting, and constructing a wind farm would take years to complete. As the B2H Transmission Line and ancillary and supporting facilities needed to deliver electricity to the site are scheduled to be operational in approximately 2031, construction of a wind farm to address the gap in electricity need is not a technically feasible option.

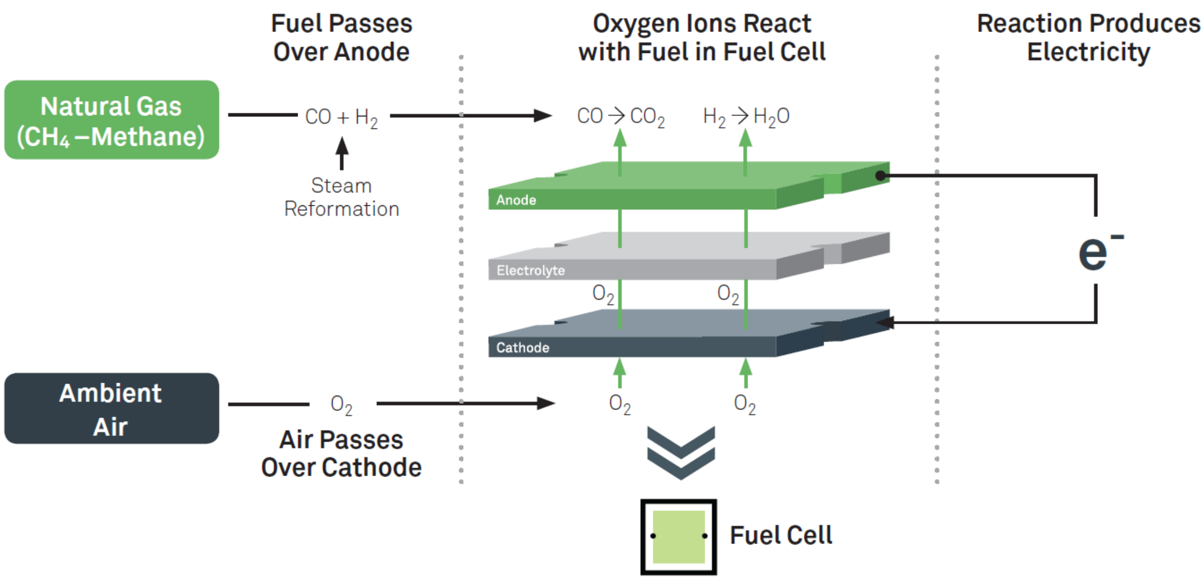
In accordance with OAR 340-271-0310, strategies considered in a BAER assessment must produce goods of comparable type, quantity, and quality. Wind energy is not a source of electricity that can be relied on with the constant demand need of the site and would not produce goods of comparable quality as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

Based on the inconsistency of the electrical generation, site limitations, and a prolonged timeline, wind energy is technically infeasible for addressing the electricity needs at PDX109 before completion of infrastructure upgrades such as the B2H Transmission Line and the ancillary and supporting facilities needed to deliver electricity to the site.

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 the following figure. The SOFC will supply the site as a supplement to the draw from the power grid.

Figure. 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 PDX109 site has access to natural gas. 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 PDX109 prior to the transmission infrastructure that will allow additional electricity to the site coming on-line.

3.2.6 Bloom Energy SOFC and CO_2 Capture

The untreated anode exhaust stream from the Bloom Energy SOFC contains approximately 49.4 percent CO_2 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 (NO_X) emissions are virtually eliminated. The following methods were considered to capture the CO_2 and process it into a marketable stream:

- Water gas shift reactor in combination with a dehydrator and further separation
- Activated carbon-based CO_2 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 CO_2 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 CO_2 stream, while activated carbon CO_2 adsorption can result in a 93 percent CO_2 stream that can be packed and sold as product. The site spoke with several potential partners to find a demand for purified CO_2, and it was determined that there is currently not enough demand in the market for CO_2 in Oregon. Exacerbating this situation is the fact that the supply is time-limited such that no new offtaker will locate in Oregon, where the source of CO_2 is not expected to exist after approximately 2031. Since there is no commercially available outlet for the captured CO_2, carbon capture and cleanup is not feasible. A letter outlining the efforts to find market demand for purified CO_2 in Oregon is included in Appendix B.

Based on the discussion above, the Bloom Energy SOFC with CO_2 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 CO_2e 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 MMBtu/day of RNG that is injected into a pipeline. The remaining operational biogas plants are consuming the supply onsite. 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. While future resources may become available in the next few years, they remain highly speculative.

If viable supplies were actually 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 life 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-megawatt-hour (MWh) 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 CO_2e 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, RNG attributes generated off site do not reduce the site's covered emissions, and so, as a matter of law, purchasing attributes cannot constitute BAER.

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.

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˚C to 1,100˚C, 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 to 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 CO_2. 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. The lack of availability is due to the challenges listed above, and the infrastructure required for industrial usage. 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. In fact, 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).

Planning, permitting, and constructing the necessary infrastructure would take 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 in 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 result, 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 PDX109 site air permit currently authorizes ADS to operate 112 emergency generators, for a total capacity of 266 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 connected to generators create significant noise issues that are fatal to their use at the ADS site where noise is a material concern. Baseload operation of 24 MW of diesel-fired electrical generation would cause substantial disturbances to the surrounding area. In addition, PDX109 would be powering its data centers with internal combustion engines, greatly increasing its GHG, criteria pollutant, and toxic emissions.

Internal combustion engines require regular maintenance and replacement of parts. 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 PDX109 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. This will result in an additional increase in criteria and hazardous air pollutants (HAPs), 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, only two 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:

1. Bloom Energy SOFC with natural gas as feedstock (679 to 833 lb CO_2e/MWh).
2. Natural gas-fired internal combustion engines connected to generators (1,199 lb CO_2e/MWh).
3. Diesel-fired internal combustion engines connected to generators (1,243 lb CO_2e/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.

The highest-ranking technology is being proposed for use as BAER. As a result, an assessment of energy, environmental, and economic impacts is not necessary. Nonetheless, an assessment of the energy, environmental, and economic impacts associated with the use of SOFC equipment with natural gas is provided below.

3.4.1 Bloom Energy SOFC Using Natural Gas as Fuel

3.4.1.1 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/yr.

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 of CO_2e/MWh. This is significantly lower than the Oregon Department of Energy's GHG emissions standard for electrical generating facilities, 1,100 lb CO_2/MWh (OAR 330-180-0030(1)) or the Oregon GHG Emissions Performance Standard (EPS) for new baseload electricity generation of 1,100 lb CO_2e/MWh (ORS 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 CO_2/MW-hour (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.

The 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.

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 2 below. The emissions assume continuous operations.

Table 1. 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
CO = carbon monoxide.
GHG = greenhouse gas.
HAP = hazardous air pollutant.
hr = hour.
lb = pound.
MWh = megawatt-hour.
NOx = 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 SO_2. The SO_2 emission factor is calculated based on the expected sulfur content in the pipeline natural gas which is 0.5 grains per 100 scf (gr S/100 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:

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

$$Rated\ Power\ = 24.3\ MW$$

3.5 Step 5—Select BAER

Based on the discussions in the previous sections, the Bloom Energy SOFC using natural gas as feedstock is BAER for on-site generation of approximately 24 MW of electricity prior to completion of the regional infrastructure improvements needed to deliver electricity to the site. Therefore, the use of the Bloom Energy SOFC using natural gas as feedstock is proposed as an electricity generation source at PDX109 until such time as electricity from the grid can be delivered to the site.

4 CONCLUSION

Table 2 provides a summary of the BAER analysis for the PDX109 data center in Boardman, Oregon.

Table 2. BAER Determination

Source	Pollutant	BAER
~24-MW electricity generation	GHG	Bloom Energy SOFC with natural gas fuel

Notes
GHG = greenhouse gas.
MW = megawatt.
SOFC = solid oxide fuel cell.

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

ADS 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 Administration[1], 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:
Nat Sahlstrom
82A582B8CF064FA...

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

legal

APPENDIX B

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 CO_2 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 CO_2 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 CO_2 affects the options available. With that background, let me summarize our analysis and efforts to date to find a use for CO_2 generated from the fuel cells.

A typical use of industrial CO_2 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 CO_2 to states/regions with such activity (e.g., California, Texas), is cost-prohibitive and the CO_2 generated by the trucks needed to transport the CO_2 would be considerable. Furthermore, in enhanced oil recovery, there is little certainty that the CO_2 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 CO_2 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.

Some parts of the country have developed bespoke CO_2 storage projects where the gas (or supercritical CO_2) 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 CO_2 that a single installation would generate. All existing CO_2 consumers have established suppliers and were not willing to consider changing supplier where the Bloom fuel cells will only be capable of providing CO_2 for a few years. In addition, and perhaps most importantly, the existing consumers of CO_2 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 CO_2 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 CO_2 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 CO_2 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