

**PUBLIC VERSION**  
**DRAFT**  
**ENGINEERING EVALUATION**

**Application No. 31209**  
**Facility ID No. 24999**  
**Mainspring Energy Inc.**  
**Cold Springs Rd & Howell Mountain Angwin, CA 94508**

**Background**

Mainspring Energy (formerly EtaGen) of Menlo Park, CA is applying for an Authority to Construct and Permit to Operate for the following equipment:

**S-1 Emergency Backup Natural Gas Linear Generator with Integral Parallel Oxidation Catalysts (Johnson Mathey, A-1 & A-2) Make: Mainspring Energy, Model: MSE-230, Maximum Output Rating: 250 kWe, Maximum Fuel Input: [REDACTED] MMBtu/hr, Emissions at P-1 & P-2 Stacks.**

Source S-1 will be located at the PG&E Angwin, CA substation (38.565162, -122.442499) to provide emergency backup power generation to PG&E during Public Safety Power Shutoff (PSPS) events. The linear generator utilizes homogenous charge compression ignition (HCCI) linear technology. Per EtaGen's United States patents for the technology underpinning source S-1 and per a review of academic and industry literature, HCCI is a form of internal combustion. A fuel mixture is injected at low temperatures into a combustion chamber and compressed until autoignition occurs. The expanding gas pushes two opposing pistons outward. These pistons have magnets attached and move through a cylinder of copper coils. The movement of the magnets creates an electrical current within the copper coils, which is then extracted to generate electricity. Air springs at the end of each piston push the pistons back to start the cycle again.

Although HCCI is a form of internal combustion, it differs from what has traditionally been considered and regulated as an internal combustion engine, either a traditional compression ignition (CI) or spark ignition (SI) engine, where use of a crank shaft is employed to create rotation about a shaft connected to an electrical generator with a similar principle as above, utilizing magnets and copper windings.

The emissions from source S-1 are nitrogen oxides (NO<sub>x</sub>), precursor organic compounds (POC), carbon monoxide (CO), particulate matter less than 10 micron (PM<sub>10</sub>) and 2.5 micron (PM<sub>2.5</sub>) in size, sulfur dioxide (SO<sub>2</sub>), and toxic air contaminants (TAC) due to combustion of natural gas.

This application proposes a new source of toxic air contaminant (TACs) and is located within 1,000 feet of the outer boundary of the nearest K-12 school (Foothills Elementary School & Pacific Union College Elementary School). Therefore, public notification pursuant to BAAQMD Regulation 2-1-412 is required.

**Emissions**

**Annual Emissions and Daily Maximum Emissions**

Source S-1 is a natural-gas fired generator that has CI engine architecture which differs from traditional diesel-fired CI engines and natural-gas fired SI engines. The combustion chamber feeds parallel exhaust paths which are controlled by discrete single catalysts and terminate respectively at exhaust points P-1 and P-2.

In previous permit application submitted by EtaGen (Mainspring Energy) (Application No. 28032), source tests conducted for a similar linear generator produced average NO<sub>x</sub> and CO concentrations of [REDACTED] at 15% O<sub>2</sub> concentration, respectively. However, NO<sub>x</sub> and CO concentration will be limited to [REDACTED]), respectively, to provide compliance margin for the linear generator.

Specific emission factors for POC and PM emissions are not available for the linear generator. BAAQMD will use the most stringent POC and PM emission factors based on requirements for CI engines. Source S-1 is expected to meet these POC and PM standards, because this source will be fueled exclusively using natural gas instead of diesel fuel.

**Table 1 – Emission Factors for Source S-1**

Pollutant	Emission Factor (lb/MMBtu)	Source of Emission Factor
NO <sub>x</sub>	█	█
POC <sup>1</sup>	█	█
CO	█	█
PM <sub>10</sub> <sup>2,3</sup>	█	█
PM <sub>2.5</sub> <sup>2,3</sup>	█	█
SO <sub>2</sub>	█	█
<sup>1</sup> Emission factor derivation: █		
<sup>2</sup> Emission factor derivation: █		
<sup>3</sup> All PM emissions emitted from the linear generators were assumed to be less than 2.5 micrometer in diameter for most conservative estimate of PM <sub>2.5</sub> emissions.		

Basis: Maximum daily █ hours/day; Maximum annual █ hours/year

**Table 2 - Annual and Daily Emissions for Source S-1**

Maximum Firing Rate (MMBtu/hr)	Pollutant	Emission Factor (lb/MMBtu)	Max Daily Emissions -Abated (lb/day)	Annual Emissions -Abated (lb/yr)	Annual Emissions -Abated (TPY)
2.31	NO <sub>x</sub>	█	0.13	48.79	0.024
	POC	█	0.29	106.46	0.053
	CO	█	0.16	59.88	0.030
	PM <sub>10</sub>	█	0.03	11.09	0.006
	PM <sub>2.5</sub>	█	0.03	11.09	0.006
	SO <sub>2</sub>	█	0.02	6.21	0.003

**Plant Cumulative Increase**

Table 3 summarizes the cumulative increase in criteria pollutant emissions that will result from the operation of S-1.

**Table 3 - Plant Cumulative Emissions**

<b>Pollutant</b>	<b>Existing Emissions Post 4/5/91 (TPY)</b>	<b>Application Emissions (TPY)</b>	<b>Cumulative Emissions (TPY)</b>
NOx	0.000	0.024	0.024
POC	0.000	0.053	0.053
CO	0.000	0.030	0.030
PM <sub>10</sub>	0.000	0.006	0.006
PM <sub>2.5</sub>	0.000	0.006	0.006
SO <sub>2</sub>	0.000	0.003	0.003

**Statement of Compliance**

**District Rules**

Regulation 1 (*General Provisions and Definitions*)

Regulation 2-1 (*Permits – General Requirements*)

Section 2-1-310 California Environmental Quality Act (CEQA)

Section 2-1-412 Public Notification

Regulation 2-2 (*Permits – New Source Review*)

Section 2-2-301 Best Available Control Technology (BACT)

Section 2-2-302 Emissions offsets

Section 2-2-304 Prevention of Significant Deterioration (PSD)

Regulation 2-5 (*Permits – New Source Review of Toxic Air Contaminants*)

Section 2-5-211 Health Risk Assessment

Regulation 6-1-302 (*Ringelmann No. 2 Limitation*)

Regulation 6-1-310.1 (*Total Suspended Particulate (TSP) Concentration Limits*)

Regulation 9-8 (*NOx and CO from Stationary Internal Combustion Engines*)

Section 9-8-502 Recordkeeping:

Section 9-8-502.1 Any person who operates any engine that is exempt from the requirements of Section 9-8-301, 302, 303, or 304 by

Section 9-8-110 or 111 shall keep records of the number of hours the engine is fired on a monthly basis.

Such records shall be retained for a minimum of 24 months from the date of entry and made available to District staff upon request

**Regulation 1: General Provisions and Definitions**

The facility is subject to Regulation 1, Section 301, which prohibits discharge of air contaminants resulting in public nuisance.

**The facility is expected to comply with this requirement.**

**Regulation 2, Rule 1: Permits – General Requirements**

**California Environmental Quality Act (CEQA)**

District Regulation 2, Rule 1, Section 310 specifies that all proposed new and modified sources subject to District permit requirements must be reviewed in accordance with CEQA requirements, except for ministerial projects or projects exempt from CEQA under Section 2-1-311. The review of proposed new source was based

on the criteria set forth in Regulation 2, Rule 1, Section 428 (“Criteria for Approval of Ministerial Permit Applications”) and based on procedures, fixed standards, and objective measurements outlined in District’s Permit Handbook and BACT workbook. The engineering review for this project requires only the application of standard permit conditions and standard emission factors in the Permit Handbook Chapters (Chapter 2.3.2 Stationary Natural Gas Engines).

**Therefore, this application is considered to be ministerial and is exempt from CEQA review.**

### **Public Notification**

District Regulation 2, Rule 1, Section 412 public notification requirements apply to applications which result in any increase in toxic air contaminant or hazardous air contaminant emissions at facilities within 1,000 feet of the boundary of a K-12 school.

This application proposes a new source of TACs and is located within 1,000 feet of the outer boundary of the nearest K-12 school (with more than 12 children enrolled). Therefore, public notification pursuant to Reg. 2-1-412 is required. Foothills Elementary School and Pacific Union College Elementary School are located within 1,000 feet of the proposed source and the District confirmed that they are active schools with more than 12 students enrolled at each one. There are no other schools within a ¼-mi. radius of the proposed project. The school public notice will therefore be distributed on [DATE] to the parents and guardians of the students of the following school as well as to addresses located within 1,000 feet of the schools:

Foothills Elementary School, 135 Neilsen Ct, Angwin, CA 94508

Pacific Union College Elementary School, 135 Neilsen Ct, Angwin, CA 94508

### **Regulation 2, Rule 2: Permits – New Source Review**

#### **Best Available Control Technology (BACT)**

Per Regulation 2, Rule 2, Section 301, BACT is required for new or modified sources with potential emissions of 10.0 lb/day or more of POC, NPOC, NO<sub>x</sub>, PM<sub>10</sub>, or SO<sub>2</sub>.

**Source S-1 does not have the potential to emit 10.0 lb/day or more of any these pollutants, therefore source S-1 does not trigger BACT.**

#### **Emissions Offsets**

Offsets must be provided for any new or modified source at a facility that has the potential to emit more than 10 tons per year of POC or NO<sub>x</sub> as specified in Regulation 2-2-302; and more than 100 tons per year of PM<sub>2.5</sub>, PM<sub>10</sub>, and SO<sub>2</sub> as specified in Regulation 2-2-303.

**The permitted emissions from the facility are less than 10 tons per year of POC or NO<sub>x</sub> and less than 100 ton per year of PM<sub>10</sub>, therefore offsets are not required.**

#### **Prevention of Significant Deterioration (PSD)**

Under this application this facility will not have the potential to emit more than 100 tons per year of any criteria pollutant.

**Therefore, this facility is not a "Major Facility" as defined in Regulation 2-1-203 and is not subject to PSD permitting requirements under Regulation 2-2-304.**

#### **Health Risk Assessment (HRA)**

Mainspring Energy provided source test results for the linear generator that indicated presence of the following toxic air contaminants (TAC) at the exhaust of the linear generator: benzene, 1,3 – butadiene, formaldehyde, hexane n-, methanol, methylene chloride, propene, toluene, and xylene. The TAC emission factors were calculated based on maximum post-catalyst concentration available from the submitted source test result.

**Table 4 – TAC Emissions based on Source Test derived TAC Emission Factors**

TAC	Max. Post-Catalyst Concentration (ppbv)	Emission Factor (lb/MMbtu)	Total Chronic Emissions (lb/yr)	Chronic Trigger Level (lb/yr)	Exceeds Chronic Trigger	Total Acute Emissions (lb/hr)	Acute Trigger Level (lb/hr)	Exceeds Acute Trigger
Benzene			6.94E-02	2.90E+00	No	7.23E-05	6.00E-02	No
Butadiene, 1,3 -			4.81E-02	4.80E-01	No	5.01E-05	1.50E+00	No
Formaldehyde			1.06E+01	1.40E+01	No	1.11E-02	1.20E-01	No
Hexane, n-			7.66E-02	2.70E+05	No	7.98E-05	-	-
Methanol			2.85E-01	1.50E+05	No	2.97E-04	6.20E+01	No
Methylene chloride			7.86E-01	8.20E+01	No	8.19E-04	3.10E+01	No
Propylene (propene)			7.48E-02	1.20E+05	No	7.79E-05	-	-
Toluene			3.72E-01	1.20E+04	No	3.87E-04	8.20E+01	No
Xylene (Total)			3.79E-01	2.70E+04	No	3.95E-04	4.90E+01	No

Referring to Table 4, source S-1 will not emit any TACs at emission rates that exceed applicable HRA trigger levels.

**Therefore, an HRA is not required.**

### Regulation 6, Rule 1: Particulate Matter – General Requirements

Sources S-1 is subject to the standards set forth in Section 301 (“Ringelmann No. 1 Limitation”), 305 (“Visible Particles”) and 310 (“Total Suspended Particulate Concentrations Limits”). Source S-1 will be fueled exclusively using natural gas.

**Source S-1 linear generator is expected to meet the requirements of Regulation 6-1-301, Regulation 6-1-305 and Regulation 6-1-310.1. Source S-1 potential to emit TSP is less than 1000 kg/yr.**

**Therefore, Regulation 6-1-310.2 does not apply.**

### Regulation 9, Rule 8 – Nitrogen Oxides and Carbon Monoxide from Stationary Internal Combustion Engines

Per Section 9-8-101, the rule applies to “stationary internal combustion engines with an output rated by the manufacturer at more than 50 brake horsepower”. Per Section 9-8-203, “rated brake horsepower” is defined as “[t]he maximum brake horsepower rating at maximum revolutions per minute (RPM) specified for the engine by the manufacturer or indicated on the engine nameplate”.

Source S-1 does not employ a crankshaft nor transfer power through a rotating shaft. As such, brake horsepower as defined in Section 9-8-203, does not apply. Source S-1 maximum permitted and expected emissions rate is below the emission limits of Section 9-8-304 by two orders of magnitude.

**Therefore, source S-1 is not subject to the requirements of Regulation 9, Rule 8.**

### New Source Performance Standards (NSPS)

*40 CFR 60, Subpart IIII (“Standards of Performance for Stationary CI Internal Combustion Engines”)*

*40 CFR 60, Subpart JJJJ (“Standards of Performance for Stationary SI Internal Combustion Engines”)*

Both 40 CFR 60 Subpart IIII (within Section 60.4219) and Subpart JJJJ (within 60.4248) define “Stationary Internal Combustion Engine as follows:

*Stationary internal combustion engine means any internal combustion engine, except combustion turbines, that converts heat energy into mechanical work and is not mobile. Stationary ICE differs from mobile ICE in that a stationary internal combustion engine is not a nonroad engine as defined at 40 CFR 1068.30 (excluding paragraph (2)(ii) of that definition), and is not used to propel a motor vehicle, aircraft, or a vehicle used solely for competition. Stationary ICE includes reciprocating ICE, rotary ICE, and other ICE, except combustion turbines.*

Neither NSPS Subpart IIII nor Subpart JJJJ have definitions for “mechanical work”. Therefore, a common dictionary definition is used. Per the Second Edition of “Dictionary of Engineering” by McGraw-Hill, mechanical work is defined as:

*“The transference of energy that occurs when a force is applied to a body that is moving in such a way that the force has a component in the direction of the body’s motion; it is equal to the line integral of the force over the path taken by the body.”*

As explained in the Background Section, source S-1 converts heat energy (from autoigniting compressed fuel) into linear motion, which is then converted into electric energy. After combusting the compressed fuel, work is done by the expanding gas on the pistons.

In a traditional internal combustion engine, pistons are connected to a connecting rod which then imparts a rotational motion to a crankshaft. In this case, mechanical work is clearly being done by the pistons on the connecting rods and thereby on the crankshaft.

For source S-1 it is not clear whether the work done by the expanding gas on the pistons may be considered “mechanical work”. A force (the expanding gas) is applied to a body (the pistons) in the direction of the body’s motion. The facility has submitted an argument and request to the U.S. EPA stating that the technology does not meet the definition of mechanical work.

However, regardless of whether source S-1 is or is not subject to the NSPS, source S-1 is expected to comply with the emissions requirement set forth in CFR 60, Subpart IIII and Subpart JJJJ. Source S-1 is an early production commercial model without a specific model year and will be used for non-emergency purposes. Thus, the emission limits for source S-1 were compared to the most stringent emission limits available for non-emergency engines in these two subparts as shown in Table 5.

The NO<sub>x</sub> and CO emissions from source S-1 will be limited to 0.022 and 0.027 lbs/MMBtu and thus, will comply with NO<sub>x</sub> and CO standard set forth in the two subparts as shown in Table 5.

**PM and POC emissions from this source are expected to be low and will comply with the PM and POC emission standards in the two subparts, since source S-1 will be fueled using natural gas instead of diesel.**

**Table 5 – NSPS Subpart IIII and JJJJ Emission Standards**

Pollutant	S-1 Emission Factors (lb/MMBtu)	Emissions Standard required per Subpart IIII for Tier 4 Final Engines		Emission Standard required per Subpart JJJJ	
		(g/kW-hr)	(lb/MMBtu)	(g/HP-hr)	(lb/MMBtu)
NO <sub>x</sub>		0.4	0.10	1	0.34
POC		0.19	0.05	0.7	0.23
CO		3.5	0.88	2	0.67
PM		0.02	0.005	-	-

**Air Toxic Control Measure for Stationary Compression Ignition Engines (ATCM)**

The purpose of the ATCM is to reduce diesel particulate matter and criteria pollutant emissions from stationary diesel-fueled CI engines.

**Source S-1 linear generator will be fueled exclusively using natural gas, therefore source S-1 is not subject to the ATCM.**

**National Emissions Standards for Hazardous Air Pollutants (NESHAP)**

40 CFR 63, Subpart ZZZZ (“National Emission Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines”) applies to stationary reciprocating internal combustion engines (RICE) at both major and area sources. The facility is not a major source and is therefore, considered an area source.

Per Section 63.6585(a), a stationary reciprocating internal combustion engine is “any internal combustion engine which uses reciprocating motion to convert heat energy into mechanical work and which is not mobile.” As described in the Background Section and within the discussion of the applicability of New Source Performance Standards, source S-1 converts heat energy into linear motion that is repeated or reciprocated through use of air springs.

Per Section 63.6590(c)(1), a new stationary RICE at an area source is subject to the requirements of 40 CFR 60 Subpart IIII (if a compression ignition engine) or 40 CFR 60 Subpart JJJJ (if a spark ignition engine). As discussed above, source S-1 is expected to meet the emission limits of both subparts.

**The facility has submitted a request to the U.S. EPA regarding the applicability of the subparts. As such, it is not known whether the sources will be required to comply with the non-emission requirements (e.g. certification, recordkeeping).**

### Permit Conditions

#### **Permit Condition #27472 for S-1**

1. The owner/operator of source S-1 shall operate this source on natural gas fuel exclusively.  
[Basis: Cumulative Increase]
2. The owner/operator of source S-1 shall not exceed natural gas fuel usage of [REDACTED] standard cubic feet in any hour.  
[Basis: Cumulative Increase]
3. The owner/operator shall not operate source S-1 more than [REDACTED] hours during any consecutive 12-month period. [Basis: Cumulative Increase, Reg 2-5]
4. The owner/operator of source S-1 shall abate this source with properly maintained and properly operated parallel oxidation catalyst abatement devices A-1 & A-2.  
[Basis: Cumulative Increase]
5. The owner/operator of source S-1 shall not exceed following emission limits:  
NO<sub>x</sub> [REDACTED] corrected to 15% oxygen, averaged over 15-minute period  
CO [REDACTED] corrected to 15% oxygen, averaged over 15-minute period  
Formaldehyde [REDACTED]  
[Basis: Cumulative Increase, Reg 2-5]
6. Within 60 days of startup, the owner/operator of source S-1 shall conduct an Air District-approved source test, both initially and annually thereafter, to determine compliance with all the emissions limits contained in Part 4. Each source test shall test for each pollutant identified in Part 4. The owner/operator of source S-1 shall submit the source test results to the Air District Staff within the 60 days after the test. When determining compliance with the formaldehyde emission limit of Part 4, a higher heating value for natural gas of 1,020 Btu per standard cubic feet shall be used.  
[Basis: Cumulative Increase]
7. The owner/operator of source S-1 shall obtain prior approval for all source test procedures from the Air District’s Source Test Section prior to conducting any test. The owner/operator shall comply with all applicable testing requirements as specified in Volume V of the District’s Manual of Procedures. The owner/operator shall notify the Air District’s Source Test Section, in writing, of the source test protocols and projected test dates at least 7 days prior to testing. [Basis: Cumulative Increase]
8. The owner/operator of source S-1 shall retain the following records on-site at least for 24 months, from the date of entry, and make them available for inspection by District staff upon request.
  - a. Fuel usage on a monthly basis for source S-1

- b. Any maintenance records for source S-1
  - c. Any maintenance records for both oxidation catalyst abatement devices A-1 & A-2
  - d. Any source test records for source S-1
- [Basis: Cumulative Increase]

**RECOMMENDATION**

The District has reviewed the material contained in the permit application for the proposed project and has made a preliminary determination that the project is expected to comply with all applicable requirements of District, state and federal air quality-related regulations. The preliminary recommendation is to issue an Authority to Construct for the equipment listed below. However, the proposed source will be located within 1,000 feet of a school, which triggers the public notification requirements of District Regulation 2-1-412. After the comments are received and reviewed, the District will make a final determination on the permit.

I recommend that the District initiate a public notice and consider any comments received prior to taking any final action on issuance of an Authority to Construct/Permit to Operate for the following source:

**S-1 Emergency Backup Natural Gas Linear Generator with Integral Parallel Oxidation Catalysts (Johnson Matthey, A-1 & A-2) Make: Mainspring Energy, Model: MSE-230, Maximum Output Rating: 250 kWe, Maximum Fuel Input: [REDACTED] MMBtu/hr, Emissions at P-1 & P-2 Stacks.**

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7/1/2021  
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