



August 25, 2020

Ms. Christy Woodward

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Via Email: christy.woodward@coga.org

RE: Engine Rulemaking Rebuttal and Technical Analysis

Dear Christy,

Spirit Environmental, LLC ("Spirit") was engaged to carefully review and respond to the expert testimony and alternate proposal presented by the National Parks Conservation Association ("NPCA") in their prehearing statement. The data and technical analyses that follow are being provided to the Colorado Oil & Gas Association ("COGA") and outside counsel representing numerous oil and natural gas operators in Colorado.

Summary of NPCA alternate proposal

NPCA submitted an alternate proposal that requests that the Air Quality Control Commission ("AQCC") adopt stricter standards for all engines by requiring that units be electrified where feasible, and that the horsepower ("hp") applicability threshold for four-stroke rich-burn engines ("4SRB") be lowered to 100 hp and greater. Spirit understands that the AQCC has directed that engines below 1000 HP are out of scope for the current rulemaking. As such, Spirit attempts, where possible, to address only those portions of NPCA's proposal related to engines equal to or greater than 1000 HP. In some instances, Spirit's responses implicate engines below 1000 HP because NPCA integrated its analysis of engines both above and below 1000 HP.

NPCA proposed the following language revisions to Regulation 7:

"I.D.5.b.(iii)(a). The owner or operator of any stationary natural gas fired reciprocating internal combustion engine shall electrify the engine unless the owner or operator shows that electrification is infeasible. The Division shall determine whether an owner or operator has demonstrated that electrification is infeasible based on information and data provided by the owner or operator, and any other information reasonably available to the Division (as applicable). In making the determination, the Division shall consider whether there is no reasonable access or opportunity to create access to the power grid, or whether the cost per ton of NOx reduction

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4SRB Alternative Proposal

NPCA's alternate proposal requests a significant change to the rule applicability by lowering the horsepower threshold from 1,000 hp and greater, to 100 hp and greater for 4SRB engines. However, as noted above, the AQCC rejected engines below 1000 HP as outside of the scope of the rulemaking. In addition, the NPCA's alternate proposal mandates NO_x emission limits of 0.2 g/hp-hr for engines greater than 500 hp (or as authorized for consideration by the AQCC, equal to or greater than 1000 HP), much lower than the Division's proposal of 0.8 g/hp-hr for existing 4SRB engines equal to or greater than 1,000 hp and 0.5 g/hp-hr for new 4SRB engines equal to or greater than 1,000.

Throughout its EIA and supporting exhibits, NPCA assumes that the only controls needed to achieve a 0.2 g/hp-hr NO_x emission rate are the addition of an air-fuel ratio controller ("AFRC") and non-selective catalytic reduction ("NSCR"). This is also what NPCA's cost estimates are exclusively based on.

Table 1 presents controlled and uncontrolled NO_x emission factor values for a range of control device efficiencies representative of 4SRB engines commonly found at oil and gas facilities. Table 1 demonstrates that the NO_x emission limits proposed by NPCA are only achievable with control devices providing greater than 98% control of NO_x.

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Table 1 – Controlled and uncontrolled 4SRB engines NO_x emission factors for a range of NSCR/AFRC control efficiencies.

NO _x Unc. EF (g/hp-hr) Control Device Efficiency	12.00	13.00	14.00	15.00	16.00
90.0%	1.20	1.30	1.40	1.50	1.60
90.3%	1.16	1.26	1.35	1.45	1.55
90.7%	1.12	1.21	1.31	1.40	1.49
91.0%	1.08	1.17	1.26	1.35	1.44
91.3%	1.04	1.13	1.21	1.30	1.39
91.7%	1.00	1.08	1.17	1.25	1.33
92.0%	0.96	1.04	1.12	1.20	1.28
92.3%	0.92	1.00	1.07	1.15	1.23
92.7%	0.88	0.95	1.03	1.10	1.17
93.0%	0.84	0.91	0.98	1.05	1.12
93.3%	0.80	0.87	0.93	1.00	1.07
93.7%	0.76	0.82	0.89	0.95	1.01
94.0%	0.72	0.78	0.84	0.90	0.96
94.3%	0.68	0.74	0.79	0.85	0.91
94.7%	0.64	0.69	0.75	0.80	0.85
95.0%	0.60	0.65	0.70	0.75	0.80
95.3%	0.56	0.61	0.65	0.70	0.75
95.7%	0.52	0.56	0.61	0.65	0.69
96.0%	0.48	0.52	0.56	0.60	0.64
96.3%	0.44	0.48	0.51	0.55	0.59
96.7%	0.40	0.43	0.47	0.50	0.53
97.0%	0.36	0.39	0.42	0.45	0.48
97.3%	0.32	0.35	0.37	0.40	0.43
97.7%	0.28	0.30	0.33	0.35	0.37
98.0%	0.24	0.26	0.28	0.30	0.32
98.3%	0.20	0.22	0.23	0.25	0.27
98.7%	0.16	0.17	0.19	0.20	0.21
99.0%	0.12	0.13	0.14	0.15	0.16

	Meets Division's proposed 0.8 g/hp-hr NO _x emission limit (>1,000 hp existing engines)
	Meets Division's proposed 0.5 g/hp-hr NO _x emission limit (>1,000 hp new engines)
	Meets NPCA's proposed 0.25 g/hp-hr NO _x emission limit (all 100-500 hp engines)
	Meets NPCA's proposed 0.2 g/hp-hr NO _x emission limit (all >500 hp engines)

While the addition of NSCR in conjunction with AFRC controls to an existing engine may provide >98% control with brand new catalyst elements and under ideal conditions, that level of control cannot be reliably maintained as catalytic elements age, and engine settings drift (within acceptable levels). This was confirmed by Innio – Waukesha, a rich-burn engine vendor familiar with Colorado oil and gas operations. Innio – Waukesha agreed that while a 4SRB engine equipped with NSCR and AFRC may be able to temporarily meet a 0.2 g/hp-hr NOx emission rate, maintaining it at those levels for ongoing compliance would be near impossible⁸. In fact, catalyst manufacturers and vendors contacted by Spirit (Miratech, Johnson Matthey, and RJ Mann) confirmed that they would only guarantee catalyst performance for at most 1 to 3 years because the catalyst elements and engine management systems must be in almost new condition to attempt to meet such a low standard and high control efficiency.

NPCA included data that supports the inability to meet these 98% reductions on an ongoing basis in Exhibit 1 – *Oil and Gas Sector Reasonable Progress Four-Factor Analysis of Controls for Five Source Categories*. Within Exhibit 1 NPCA's experts note the following: "For example, retrofit installations of NSCR on five Caterpillar rich burn engines in Texas achieved a NOx reduction of 96% or greater on all of the engines. On two of those engines, testing conducted after more than 4,000 hours of operation with NSCR indicated the NSCR controls were still achieving a 95% NOx reduction." However, as shown by Table 1 and based on NPCA's own assumptions regarding the g/hp-hr for uncontrolled engines, 95 to 96 percent will not achieve the necessary limits. In NPCA's Exhibit 3 - *Initial Economic Impact Analysis (EIA) for A Proposal To Regulate NOx Emissions from Natural Gas Fired Rich-Burn Natural Gas Reciprocating Internal Combustion Engines (RICE) Greater Than 100 Horsepower*, Dr. Sahu recognizes that 4SRB engines pre-control emissions generally range from 15 to 16 g/hp-hr and claims that the proposed 0.2 g/hp-hr NOx emission limits are achievable for all 4SRB engines. Yet the references cited by Dr. Sahu to support this claim indicate that a 90% reduction of nitrogen oxides is state of the art emission performance level for existing RICE fueled by natural gas⁹ and that 95% control of NOx may be assumed when evaluating the cost-effectiveness of NSCR/AFRC controls¹⁰, yielding a 0.75 g/hp-hr NOx emission level at best.

A more realistically achievable level of control using NSCR in conjunction with AFRC lies in the range of 90%-95%¹¹. Table 1 above demonstrates that, unlike NPCA's proposed limit, the

⁸ Verbal conversation with Innio/Waukesha dated 08/11/2020.

⁹ NJ DEP State of the Art (SOTA) Manual for Reciprocating Internal Combustion Engines (2003), at 4-5.

¹⁰ Commonwealth of Pennsylvania, Final Technical Support Document (June 2018) for the General Plan Approval and/or General Operating Permit for Unconventional Natural Gas Well Site Operations and Remote Pigging Stations (BAQ-GPA/GP-5A, 2700-PM-BAQ0268); and the Revisions to the General Plan Approval and/or General Operating Permit for Natural Gas Compressor Stations, Processing Plants, and Transmission Stations (BAQ-GPA/GP-5, 2700- PM-BAQ0267), at 34.

¹¹ Stationary Reciprocating Internal Combustion Engines - Updated Information on NOx Emissions and Control Techniques, EPA-457/R-00-001, September 2000.

Division's proposed 0.8 g/hp-hr NO_x limit for existing engines equal to or greater than 1,000 hp can be achieved using NSCR and AFRC. Spirit also agrees that these two controls are readily available and reasonable to install on new and existing 4SRB engines to reduce NO_x emissions. For new 4SRB engines >1,000 hp, the Division's proposed 0.5 g/hp-hr NO_x limit is achievable through the use of NSCR/AFRC in conjunction with engine combustion improvements that have become common as part of the design of a new engine from the outset.

For existing 4SRB engines to consistently meet a NO_x emission level of 0.2 g/hp-hr, other significant equipment upgrades, in addition to an AFRC and/or NSCR installation, would need to be made. These engine upgrades were not accounted for in the NPCA's EIA. Engine upgrade kits may be used to replace several major components on the existing engine (e.g. pistons, heads, turbocharger, emission management system, flywheel etc.), and work in conjunction with a traditional NSCR/AFRC system to further bolster the ability to achieve a 0.2 g/hp-hr NO_x emission rate. However, even those NPCA's proposal does not even consider these costs, or attempt to determine the range of such costs. Such costs could be in the hundreds of thousands of dollars for engines that are low emitting – representing an extensive and expensive total cost to operators and potentially high cost-per-ton reduced. This is a significant cost to the oil and natural gas industry where operators are largely already controlling engines and is a significant additional cost to achieve the minimal additional reductions that would result.

Additionally, the cost analyses prepared by NPCA's experts or cited throughout their exhibits were overwhelmingly based on an annualized NSCR/AFRC cost estimate from a memo by E^C/R Incorporated. For this memo, E^C/R Incorporated collected capital cost data for retrofitting NSCR/AFRC on existing 4SRB engines from industry groups, vendors, and manufacturers of RICE control technology for engines in the 50 to 3,000 horsepower range. However, in actuality, the direct and indirect annual cost data in this memo was obtained from an INGAA/API Technical Report¹² based on a dataset which was limited to engines less than 500 hp. These direct and indirect annual costs for engines in the 300-500 hp range from the INGAA/API Technical Report were applied by E^C/R Incorporated to any engine above 300 hp, including up to 3,000 hp. This is inappropriate, because direct and indirect annual costs increase with the engine horsepower, and the use of this data results in a gross underestimation of direct and indirect annual costs for engines equal to or greater than 1,000 hp, which are the main focus of our review.

Finally, NPCA's calculated cost is based on an underestimate of the total number of engines that will require retrofit in order to meet their alternate proposal. First, NPCA excluded from their cost estimate engines that, based on Division's APEN data, appeared to not be operating. Such engines are usually present at existing facilities to provide redundancy or backup capacity. Though they may not operate in certain given years, such engines would still need to be available

¹² Emission Control Cost Analysis Background for "Above the Floor" Emission Controls for Natural Gas-Fired RICE, Attachment D. Available at: https://downloads.regulations.gov/EPA-HQ-OAR-2008-0708-0279/attachment_1.pdf.