Illinois Environmental Protection Agency
Bureau of Air, Permit Section
Springfield, Illinois

Project Summary for a Construction Permit Application from Hoosier Energy, LLC, for a Landfill Gas-to-Energy Facility at the Orchard Hills Landfill Davis Junction, Illinois

Facility Identification No.:	141017AAG
Application No.:	11050042
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Schedule

Public Comment Period Begins:	July 12, 2012
Public Comment Period Closes:	August 11, 2012

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PROJECT SUMMARY

I. INTRODUCTION

Hoosier Energy REC, Inc. (Hoosier), has applied for a construction permit for a landfill gas-to-energy facility at the Veolia Orchard Hills Landfill. The facility would have seven reciprocating engine generators and use treated landfill gas (LFG) from the Orchard Hills Landfill as fuel.

The Illinois EPA has prepared a draft of the construction permit that it would propose to issue for the proposed facility. Prior to issuing any permit, the Illinois EPA is holding a public comment period to receive comments on the terms and conditions of the draft permit.

II. PROJECT DESCRIPTION

The proposed facility would have seven reciprocating engines and combust landfill gas (LFG) collected from the landfill to generate electricity. The gross electrical output of the facility would nominally be 19.1 MW. The electricity from the facility will go to the electrical transmission grid. The facility would be located on property leased from the Veolia Orchard Hills Landfill. Collected LFG that cannot be used at the proposed facility would be handled at the landfill, as currently occurs.

Before being used as fuel in the engines, LFG collected from the landfill would first be processed in a treatment system to prepare the LFG for use as fuel, by filtering and dewatering the LFG. A sulfur removal system (“sulfur system”) would then be used if needed to remove hydrogen sulfide (H_2S) from the fuel gas before it is used in the engines. The sulfur system would be designed to maintain the total sulfur level in the treated LFG used as fuel to no more than 140 ppm (as sulfur). The sulfur removal system functions as a pollution control device, to reduce emissions of sulfur dioxide (SO_2). This system would have insignificant emissions of sulfur dioxide (SO_2).

Another system would be present that may be used to remove siloxanes (organic silicon compounds) from the gas before it is used as fuel. LFG contains organic silica compounds called siloxanes, which are present in various healthcare and personal hygiene products that are disposed of in the landfill. Siloxanes form silica as a result of combustion. Silica can deposit on the wall of the engine combustion chamber and build up over time. This results in increased engine maintenance with more frequent major engine overhauls. Analysis of the LFG from the Orchard Hills landfill indicates that siloxanes may be present in concentrations that warrant their removal prior to use of LFG as fuel in the engines. This siloxane removal system (“siloxane system”) would have emissions of off-gas from periodic regeneration of the adsorption beds, which would be controlled with a combustor. A combustor or thermal oxidizer will be used to combust the off-gas from the siloxane system. The oxidizer is designed to control off-gas from the siloxane system by combusting siloxanes and other VOM compounds in the off-gas. The oxidizer would be fired with treated LFG and is expected to run at most 50 percent of the time.

The treated and processed LFG would go to the seven engine-generators. The engines proposed are Jenbacher internal combustion engines. They are spark ignition engines designed to fire LFG. Each engine will vent through its own stack. Assuming sufficient LFG from the landfill, the engines will operate continuously with downtime for maintenance. The engines will be housed in a building.

III. PROJECT EMISSIONS

The potential emissions of the proposed facility are listed below. Potential emissions are calculated based on continuous operation of the facility. Actual emissions will be less to the extent that the facility does not operate at its capacity and operates with a reasonable margin of compliance.

Permitted Emissions of the Facility

Pollutant	Potential Emissions (Tons Per Year)
Particulate Matter (PM)	26.9
Particulate Matter $PM_{10}/PM_{2.5}$	26.6
Nitrogen Oxides (NO_x)	157.5
Carbon Monoxide (CO)	648.1
Volatile Organic Material (VOM)	181.1
Sulfur Dioxide (SO_2)	39.9
Hazardous Air Pollutants (HAPs)	111.3

IV. APPLICABLE EMISSION STANDARDS

The Illinois EPA has reviewed Hoosier’s application and made a preliminary determination that the application for the proposed project will comply with applicable federal and state emission standards, including applicable federal emission standards adopted by the United States EPA (40 CFR Part 60) and the emission standards of the State of Illinois (35 Ill. Adm. Code: Subtitle B, Subchapter c.

The facility will comply with the federal New Source Performance Standards (NSPS) for Municipal Solid Waste Landfills, 40 CFR 60, Subpart WWW. The facility’s engines would be subject to the requirements of the federal New Source Performance Standards (NSPS) for Stationary Spark Ignition Internal Combustion Engines, 40 CFR 60, Subpart JJJJ. The Illinois EPA administers the NSPS in Illinois on behalf of the United States EPA under a delegation agreement.

V. APPLICABILITY OF PREVENTION of SIGNIFICANT DETERIORATION (PSD)

The proposed facility is a major modification at an existing major source, so the project will be subject to the federal rules for Prevention of Significant Deterioration (PSD), 40 CFR 52.21. The proposed facility is a major modification for emissions of NO_x, VOM, CO and $PM/PM_{10}/PM_{2.5}$, with potential annual emissions of more than 40 tons for NOx and VOM, 100 tons for CO and 25/15/10 tons for $PM/PM_{10}/PM_{2.5}$. The proposed facility would not be a major project for emissions of greenhouse gases (GHG) as carbon dioxide equivalents (CO_2e). Although potential annual emissions would be more than 100,000 tons per year, USEPA has deferred applicability of PSD to CO_2 emissions from combustion of LFG and other biogenic CO_2 emissions until July 2014.

Lastly, because emissions of sulfuric acid mist, hydrogen sulfide and reduced sulfur compounds will be well below their respective significance thresholds of 7, 10 and 10 tons per year, PSD will not apply for these pollutants.

The facility will utilize the Best Available Control Technology (BACT) to reduce emissions of pollutants that are subject to PSD from the facility. The air quality modeling for these pollutants demonstrates that the facility will not cause violations of the National Ambient Air Quality Standards (NAAQS) or applicable PSD increment.

VI. BEST AVAILABLE CONTROL TECHNOLOGY (BACT)

Under the PSD rules, a project that is subject to PSD must control emissions of pollutants subject to PSD with Best Available Control technology (BACT). Hoosier has provided a BACT demonstration in its application addressing emissions of pollutants that are subject to PSD, i.e., NO_x, VOM, CO, $PM/PM_{10}/PM_{2.5}$.

BACT is defined by Section 169(3) of the federal Clean Air Act as:

> An emission limitation based on the maximum degree of reduction of each pollutant subject to regulation under this Act emitted from or which results from any major emitting facility, which the permitting authority, on a case-by-case basis, taking into account energy, environmental and other costs, determines is achievable for such facility through application of production processes and available methods, systems and techniques, including fuel cleaning, clean fuels, or treatment or innovative fuel combustion techniques for control of each such pollutant.

BACT is generally set by a “Top-Down Process.” In this process, the most effective control option that is available and technically feasible is assumed to constitute BACT for a particular unit, unless the energy, environmental and economic impacts associated with that control option are found to be excessive. A demonstration of BACT for pollutants that are subject to PSD was provided in the permit application. The proposed determination of BACT by the Illinois EPA is discussed in Attachments 1 and 2 for the engines and the siloxane system, respectively. The draft permit includes proposed BACT limits, which have generally been determined based on the following:

- Emission data provided by the applicant;
- The demonstrated ability of similar equipment to meet the proposed emission limits or control requirements;
- Compliance periods associated with limits that are consistent with those used by USEPA in recent NESHAP rules for engines; and
- Review of emission limits and control efficiencies required of other engines as reflected in USEPA’s *RACT/BACT/LAER Clearinghouse*.

An important resource for BACT determinations is USEPA’s RACT/BACT/LAER Clearinghouse (Clearinghouse), a national compendium of control technology determinations maintained by USEPA. Other documents that are consulted include general information in the technical literature and information on other similar or related projects that are proposed or have been recently permitted.

For the proposed project, another important resource for the BACT determinations was USEPA’s recent NSPS rulemakings for reciprocating engines.

VII. AIR QUALITY IMPACT ANALYSIS

a. Introduction

The previous discussions addressed emissions and emission standards. Emissions are the quantity of pollutants emitted by a source, as they are released to the atmosphere from various emission units. Standards are set limiting the amount of these emissions as a means to address the presence of contaminants in the air. The quality of air that people breathe is known as ambient air quality. Ambient air quality considers the emissions from a particular source after they have dispersed following release from a stack or other emission point, in combination with pollutants emitted from other nearby sources and background pollutant levels. The level of pollutants in ambient air is typically expressed in terms of the concentration of the pollutant in the air. One form of this expression is parts per million. A more common scientific form is in micrograms per cubic meter, which are millionths of a gram by weight of a pollutant contained in a cubic meter of air.

The USEPA has established standards for the level of various pollutants in the ambient air. These ambient air quality standards are based on a broad collection of scientific data to define levels of ambient air quality where adverse human health impacts and welfare impacts may occur. As part of the process of adopting air quality standards, the USEPA compiles scientific information on the potential impacts of the pollutant into a “criteria” document. Hence the pollutants for which air quality standards exist are known as criteria pollutants. Based upon the nature and effects of a pollutant, appropriate numerical standards(s) and associated averaging times are set to protect against adverse impacts. For some pollutants several standards are set, for others only a single standard has been established.

Areas can be designated as attainment or nonattainment for criteria pollutants, based on the existing air quality. In an attainment area, the goal is to generally preserve the existing clean air resource and prevent increases in emissions which would result in nonattainment. In a nonattainment area efforts must be taken to reduce emissions to come into attainment. An area can be attainment for one pollutant and nonattainment for another.

Compliance with air quality standards is determined by two techniques, monitoring and modeling. In monitoring, one actually samples the levels of pollutants in the air on a routine basis. This is particularly valuable as monitoring provides data on actual air quality, considering actual weather and source operation. The Illinois EPA operates a network of ambient air monitoring stations across the state.

Ambient monitoring is limited because one cannot operate monitors at all locations. One also cannot monitor to predict the effect of a future source, which has not yet been built, or to evaluate the effect of possible regulatory programs to reduce emissions. Modeling is used for these purposes. Modeling uses mathematical equations to predict ambient concentrations based on various factors, including the height of a stack, the velocity and temperature of exhaust gases, and weather data (speed, direction and atmospheric mixing). Modeling is performed by computer, allowing detailed estimates to be made of air quality impacts over a range of weather data. Modeling techniques are well developed for essentially stable pollutants like particulate matter, NO_x, and CO, and can readily address the impact of individual sources. Modeling techniques for reactive pollutants, e.g., ozone, are more complex and have generally been developed for analysis of entire urban areas. They are not applicable to a single source with small amounts of emissions.

Air quality analysis is the process of predicting ambient concentrations in an area as a result of a project, and comparing the concentration to the air quality standard or other reference level. Air quality analysis uses a combination of monitoring data and modeling as appropriate.

b. Air Quality Analysis for NO_2, $PM_{2.5}$ and CO

An ambient air quality analysis was conducted by the consulting firm, Golder Associates Inc., on behalf of Hoosier Energy to assess the impact of the emissions of the proposed project. This analysis determined that the proposed project will not cause or contribute to a violation of any applicable air quality standard.

Modeling Procedure

Step 1 - Significance Analysis: The starting point for determining the extent of the modeling necessary for any proposed facility is evaluating whether the facility would have a “significant impact”. The PSD rules identify Significant Impact Levels (SIL), which represent thresholds triggering a need for more detailed modeling.[1] These thresholds are specified for all criteria pollutants, except ozone and lead.

Step 2 - Refined (Full Impact) Analysis: For pollutants for which impacts are above the SIL, more detailed modeling is performed by incorporating proposed new emissions units at the proposed

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[1] The significant impact levels do not correlate with health or welfare thresholds for humans, nor do they correspond to a threshold for effects on flora or fauna.

facility, stationary sources in the surrounding area (from a regional inventory), and a background concentration.

Step 3 - Refined Culpability Analysis: For pollutants for which the refined (full impact) modeling continues to indicate a modeled exceedance of a NAAQS, a more refined culpability analysis is performed incorporating additional specific procedures consistent with U.S. EPA guidance.

Table 1 shows the results of the Step 1 significance analysis

Table 1 – Step 1 Significance Analysis Results (μg/m^3)

Pollutant	Averaging Period	Maximum Predicted Impact	Significant Impact Level
NO_2	1-hour	70.8	7.52*
NO_2	Annual	2.5	1
PM_{10}	24-hour	11.1	5
PM_{10}	Annual	N/A**	N/A
$PM_{2.5}$	24-hour	9.4	1.2
$PM_{2.5}$	Annual	0.6	0.3
SO_2	1-hour	23.4	7.85*
SO_2	3-hour	23.1	25
SO_2	24-hour	14.2	5
SO_2	Annual	0.8	1
CO	1-hour	369	2,000
CO	8-hour	318	500

*interim Significant Impact Level
**the NAAQS for PM_{10} has been rescinded

The significance analysis (Step 1) results demonstrate that all impacts over all averaging periods for CO are insignificant and no refined (full impact) analysis is required for these pollutants. As modeling results demonstrate that impacts are significant for 24-hour PM_{10}, 24-hour and annual $PM_{2.5}$, 1-hour and 24-hour SO_2, and for the 1-hour and annual NO_2 averaging periods, a refined (full impact) analysis (Step 2) was performed for these pollutants and averaging periods.

PM_{10} – Annual & 24-hour

The Step 2 refined (full impact) analysis demonstrates that the project would not cause or contribute to a violation of the NAAQS (24-hour only) or applicable PSD increment(s) for PM_{10}.

Under Step 2, for the 24-hour $PM_{2.5}$ NAAQS analysis, modeled $PM_{2.5}$ concentrations, considering the project emissions, emissions from regional inventory sources, and an additional background monitored concentration, a modeled exceedance of the NAAQS occurred at numerous modeled receptor locations. Further Step 3 culpability analysis of these NAAQS exceedance receptor locations determined that at all of the modeled receptor locations, the proposed facility’s impact were less than significant during the time period of the modeled exceedances.

Under Step 2, for the annual $PM_{2.5}$ NAAQS analysis, no exceedances of the annual PM_{10} NAAQS standard were predicted.

NO_2 - 1-hour

Under Step 2, for the 1-hour NO_2 NAAQS analysis, considering the project emissions, emissions from regional inventory sources, and an additional background monitored concentration, a modeled exceedance of the NAAQS occurred at several modeled receptor locations. Further Step 3 culpability analysis of these NAAQS exceedance receptor locations determined that Hoosier Energy’s contribution to the 1-hour NO_2 NAAQS, are insignificant.

NO_2 - Annual

The Step 2 refined (full impact) analysis demonstrates that the project would not cause or contribute to a violation of the NAAQS or applicable PSD increment(s) for annual NO_2.

SO_2 - 1-hour, 3-hour, 24-hour & Annual

Hoosier will not have significant emissions for SO_2 (i.e., over 40 tpy), therefore modeling under PSD is not required. Modeling was however performed, and significant impacts occurred for the 1-hour and 24-hour averaging times. Those impacts were well under the NAAQS for these averaging times, even when a conservatively determined background concentration from a nearby SO_2 monitor was added to the modeled concentration.

c. Vegetation and Soils Analysis

Hoosier Energy provided an analysis of the impacts of the proposed facility on vegetation and soils. The first stage of this analysis focused on the use of modeled air concentrations and published screening values for evaluating exposure to flora from selected criteria pollutants (NO_x, CO, SO_2, PM_{10} and $PM_{2.5}$). These screening values or threshold ambient concentrations (which may indicate levels of potential adverse impacts) are provided for “sensitive”, “intermediate”, and “resistant” species. The applicant has conservatively compared maximum modeled concentrations against “sensitive” species threshold concentrations, and in all instances, modeled impacts are below the “sensitive” value thresholds.

Potential adverse impacts to soil and vegetation from deposition of hazardous air pollutants (trace elements including hazardous metals) are the focus of the methodology. In this stepwise process, soil (depositional) loadings calculated from annual average air concentrations (modeling results) are combined with published endogenous soil concentration data and compared against threshold impact information. Dispersion modeling results were obtained for long-term averaging periods for trace metals, acid gases, and organics. Annual average concentrations were converted to deposited soil concentrations and plant tissue concentrations and compared against guideline benchmark levels for soil and plants. In all cases, the pollutant levels were less than the benchmark levels.

The proposed facility's emissions are not expected to result in harmful effects to the soils and vegetation in the area. Maximum modeled impacts for NO_x, CO, SO_2, PM_{10} and $PM_{2.5}$ do not exceed the guideline benchmark concentrations. Maximum soil impacts due to emissions of compounds of potential concern, such as sulfates, nitrates, trace metals and particle-phase semi-volatile organic compounds, are predicted to be well below measured background levels and ecological screening levels.

Consultation between the Illinois EPA and the Illinois Department of Natural Resources, as required under Illinois' Endangered Species Act, have been conducted with regard to a review of the above conclusions with respect to species of vegetation and animals that are endangered within the vicinity of the facility. The Department has concluded that adverse effects are unlikely.

The United States Fish and Wildlife Service, as required under the United States Endangered Species Act, reviewed the above conclusions with respect to species of vegetation and animals that are present in the area and indicated that there will be no adverse effects.

d. Construction and Growth Analysis

Hoosier provided a discussion of the emissions impacts resulting from residential and commercial growth associated with construction of the proposed facility. Anticipated emissions resulting from residential, commercial, and industrial growth associated with construction and operation of the proposed facility are expected to be low. Emissions associated with new residential construction, commercial services, and supporting secondary industrial services are not expected to be significant as the facility will draw from the existing work force and will be supported by the existing infrastructure. Thus, impacts would be minimal and distributed throughout the region.

VIII. DRAFT PERMIT

The Illinois EPA has prepared a draft of the construction permit that it would propose to issue for this facility. The conditions of the permit set forth the emission limitations of the facility and the air pollution control requirements that the facility must meet. These requirements include the applicable emission standards that apply to the various units at the facility. They also include the measures that must be used and the emission limits that must be met for emissions of different regulated pollutants from the facility.

Limits are set for the emissions of various pollutants from the facility. In addition to annual limits on emissions, the permit includes short-term emission limits and operational limits, as needed to provide practical enforceability of the annual emission limits. As previously noted, actual emissions associated with the facility would be less than the permitted emissions to the extent that the facility operates at less than capacity and control equipment normally operates to achieve emission rates that are lower than the applicable standards and limits.

The permit would also establish appropriate compliance procedures for the project, including requirements for emission testing, required work practices, operational monitoring (e.g., continuous or parametric emissions monitoring on the engines for NO_x, SO_2, filterable PM, CO, and non-methane hydrocarbons (NMHC)), recordkeeping, and reporting. These measures are imposed to assure that the operation and emissions of the gas-to-energy facility are appropriately tracked to confirm compliance with the various limitations and requirements established for individual units.

IX. REQUEST FOR COMMENTS

It is the Illinois EPA's preliminary determination that the application for the proposed facility meets applicable state and federal air pollution control requirements, subject to the conditions in the draft permit. The Illinois EPA is therefore proposing to issue a construction permit for the facility. Comments are requested on this proposed action by the Illinois EPA and the conditions of the draft permit.

ATTACHMENT 1

BACT Discussion for the Engines

This attachment provides a discussion of the proposed determination of BACT for the engines for pollutants that would be subject to PSD (i.e., NO_x, CO, VOM and $PM/PM_{10}/PM_{2.5}$).

Section 1 – BACT Discussion for the Engines

A. Selection of Process Technology

Hoosier Energy chose the use of reciprocating engines as the fundamental design for this project to meet its goal to generate electricity. Use of combustion turbines and steam generators (boilers) are outside the scope of the BACT definition since they are fundamentally different technologies that may be cleaner technologies for some pollutants than engines. Regardless, while the Illinois EPA has the discretion under the PSD rules to evaluate turbines and steam generating units as possible alternatives, the Illinois EPA chose not to exercise this discretion here.

First, boilers must be oversized to handle the increased air and fuel volume required for the “low Btu gas” combustion. The fuel combustion system (the burner) must also be designed to handle a moist, high volume fuel. LFG has half the energy of a similar volume of natural gas which means that a boiler and the burner must be larger than a comparable unit firing natural gas.[2] Boilers are also designed to operate efficiently at a constant level of operation. Changes in LFG quality and quantity can make this difficult. Similarly, boilers (1) are the least flexible to match the LFG supply. Boilers/turbine systems are larger than any of the other systems, thereby affecting their use at landfills; (2) have more components that can fail and are not easily replaced if a malfunction were to occur; (3) are more complex to maintain and are down longer for scheduled maintenance periods than engines; and (4) have a greater parasitic load than comparable engines systems.

Combustion turbines can adjust effectively to fluctuations in LFG quality and can reliably produce electrical energy. However, combustion turbines lack many of the qualities found in engines.

For instance, combustion turbines (1) cannot match the changes in landfill gas supply as easily because combustion turbines are larger than engines. Generally, two (or more) engines are needed to equal the production rate of one combustion turbine. If, for example, there is enough LFG for three engines, only one combustion turbine could be installed, leaving approximately one third of the LFG unusable for electrical energy generation; (2) can be removed and used elsewhere if insufficient landfill gas is available, however, a combustion turbine would have to be online longer (compared to a comparable engine system) even though it becomes less efficient as the fuel supply declines; (3) provide less flexibility should a turbine malfunction. The shutdown of a larger combustion turbine means a larger loss in production when compared to the malfunction of an engine. For example, if a combustion turbine produces 5 MW of electricity and it takes

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[2] Engines pass approximately the same volume of fuel through the combustion system, however, the combustion results in less mechanical energy produced and thereby less electrical energy.

two engines to do the same, a turbine malfunction results in the loss of 5 MW while the malfunction of one engine is 2.5 MW; (4) are more complex and are more difficult to replace than engines should a failure of the system occur; (5) are more complex to maintain and are down longer for scheduled maintenance than engines; and (6) have a greater parasitic load than comparable engines systems.

Reciprocating engines are the primary process technology used in landfill gas-to-energy facilities. There are a variety of sizes and engine configurations available to meet the needs of a small landfill generating system to a large system such as this facility. The number and type of engines used are based on the availability and reliability of the LFG flow over a period of time. Landfill gas engines have become the technology of choice over combustion turbines and boilers. A query of the US EPA’s Landfill Methane Outreach Program (LMOP) database was conducted. The database was filtered to remove projects that do not generate electricity, were constructed prior to 2002, and are not either currently under construction or operation. The resulting list indicates that there are 441 total landfill gas projects that meet the criteria above and of the 441, 350 of them use reciprocating engines (79%). The remaining 21% included turbines, boilers, cogeneration or other technologies. Technical advances in metallurgy, turbo charging, spark plug design, manifold design and integrated electronic controls result in more efficient, powerful and durable engines.

Landfill engines are the most effective system for energy conversion at landfills because engines (1) can be easily added as the LFG supply increases. Landfill gas supplies tend to be variable and full development of a landfill gas resource may take years. Engines can be added as necessary to meet the increased availability of LFG; (2) can be removed (and reused elsewhere) as the LFG supply declines; (3) can be removed and replaced without difficulty should an engine fail; (4) are easy to maintain with the primary effort being changing of lubricant oil and spark plugs; (5) require limited operator attention. Generally, engine systems require operator attendance for one shift per day; (5) can adjust to changes in landfill gas quality; (6) have low parasitic load (the electrical energy used at the Facility before placing it on the grid) relative to other electric generating technologies and (7) are the most common electric generation method found at landfills.

Given the modular nature of the systems, the ease of operation and the extensive experience, internal combustion engines are the most significant system for use in the landfill-gas-to-energy business and are the best system for use at the Landfill. In addition, rich-burn engines are not designed for large purpose uses, such as those for this project. Jenbacher and Caterpillar, two major producers of engines, do not manufacture rich-burn engines much larger than 400 kW, principally because there is no market for thaam. Aside from rich-burn engines being infeasible because they are sized to small for this project, they are much less energy efficient than lean-burn engines.

Use of a lean-burn engine was selected as the feasible technology for converting LFG into electricity.

B. Control Technology for the Engines

1. Nitrogen Oxides (NO_x)

To control NO_x emissions from the engines, the following technologies were considered available and further evaluated: (1) low-NOx burners, (2) staged-overfire air, (3) flue gas recirculation, (4) staged combustion, (5) SCONOX, (7) good combustion practices, (8) catalytic oxidation, (9) selective catalytic reduction (SCR), (10) non-selective catalytic reduction (NSCR), and (11) selective non-catalytic reduction (SNCR).

While low-NOx burners, staged overfire air, flue gas recirculation, and staged combustion are feasible technologies for boilers, they are infeasible for engines due to the inherent design of engines.

SCONOX is an infeasible technology because it is only used for natural gas-fired combustion turbines and LFG would foul the catalyst.

By using good combustion practices, CO formation is minimized when the engine temperature and oxygen levels in the combustion zones of the engine are adequate for complete combustion.

In general, SCR is a very effective add-on control technology to reduce NO_x emissions from coal-fired boilers. However, it has not yet been successfully implemented on a landfill gas-fired combustion engine. SCR involves the injection of ammonia or urea into the flue gases at an appropriate location downstream of the combustion zone within the appropriate temperature profile, whereby the ammonia reacts with NO_x in the presence of a catalyst, to produce nitrogen and water. SCR could be fitted on engines after the insertion of flue gas reheating and associated equipment. Applying an SCR to these types of flue gases leads to the catalyst being fouled, preventing the effective use of the catalyst. The primary problem, in general, is the wide range of substances in the LFG that can “contaminate” the catalyst. Even with the STS and the SRS equipment, the LFG contains particles and trace constituents that build up and require the premature replacement of the SCR catalyst.

Non-Selective Catalytic Reduction (NSCR) has been used to control NOx emissions from rich-burn engines for over 25 years and has been installed on over 3,000 rich-burn engines in the U.S. alone. The system converts NOx, CO, and nonmethane hydrocarbons in the exhaust stream to nitrogen, carbon dioxide, and oxygen using a catalyst bed. In order for proper conversion, the engine must operate in a rich burn mode. NSCR is considered technologically infeasible due to the lean burn design of the Jenbacher engines. [Note that NSCR is not the same technology as Selective Noncatalytic Reduction (SNCR), the latter does not utilize a catalyst.]

Selective Non Catalytic Reduction (SNCR) is a method to reduce nitrogen oxide emissions that involves injecting either ammonia or urea into the post-combustion gases at a location where the flue gas is between 1,400 and 2,000°F to react with the nitrogen oxides formed in the combustion process. The resulting product of the chemical reaction is elemental nitrogen (N_2), carbon dioxide (CO_2), and water (H_2O). SNCR is a proven and reliable technology already used in boilers and within the cement industry that has been shown to reduce NOx emissions to as high as 65 to 70 percent. However, for internal combustion engines, there is no place to install such a unit. In addition an SNCR requires adequate resident time for the ammonia or urea to react, which is not possible with engines. Therefore, SNCR is an infeasible technology for engines.

Ranking the feasible technologies, a lean-burn LFG-fired engine was selected as providing the best reduction of NO_x.

The resulting BACT level of control for NO_x, considering the use of lean-burn engine technology, source variability, and supported by the permit application, is proposed to be set at 0.6 grams/hp-hr (30-day rolling average).[3]

The RACT/BACT/LAER Clearinghouse was also consulted for similar operations to review required control technologies across the United States. The Clearinghouse indicated that the proposed NO_x BACT limit for the engines would be among the lowest rates listed in the Clearinghouse.[4]

2. Carbon Monoxide (CO)

The following CO control technologies are analyzed for possible applicability to the proposed engines: SCONOX, good combustion practices/lean burn combustion, catalytic oxidation, post-combustion thermal oxidation (e.g., afterburner, flare), and nonselective catalytic reduction (NSCR). The consideration of excess air was already determined when lean-burn design was already chosen since rich-burn design was found to be infeasible.

The feasible technologies that have not already been addressed earlier are catalytic oxidation and post-combustion thermal oxidation (e.g., afterburner, flare).

Catalytic oxidation is a very recently applied alternative for the treatment of CO in air streams from engines. The addition of a catalyst accelerates the rate of oxidation by adsorbing the oxygen and the contaminant on the catalyst surface where they react to form carbon dioxide and water. The catalyst enables the oxidation reaction to occur at much lower temperatures than required by a conventional thermal oxidation. CO is/are thermally destroyed at temperatures typically ranging from 320° to 540° C (600° to 1,000° F) by using a solid catalyst.

Post-combustion thermal oxidation reduces CO emissions by supplying adequate heat and sufficient oxygen to ensure that the CO is converted to CO_2. Temperatures of 1450–1600°F must be achieved to reach a rate of CO reduction of 95 percent. In catalytic oxidation, the combustion gases pass over a catalyst where the CO is converted to CO_2. One key difference between catalytic oxidation and thermal oxidation is that catalytic oxidation can operate at a much lower temperature than

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[3] See 75 FR 51570, August 20, 2010, National Emissions Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines and Standards of Performance for Spark Ignition Internal Combustion Engines for a recent discussion by USEPA of source variability and best demonstrated technology for reciprocating engines.

[4] Most notably, Hoosier identified the permit for an engine at the Brevard County Central Disposal Facility (permit no. 0090069-010-AV) in Brevard County, Florida. The NO_x emission limit established in that recent permit helped serve as one of the bases to set BACT for the proposed engine, and is numerically the same.

thermal oxidation. While thermal/catalytic oxidation has been applied to coating lines and other organic material emitting processes, it has not been widely used on engines. For these reasons, thermal/catalytic oxidation is not a feasible control technique to control CO from engines.

The only technologies that are feasible from the above available technologies were catalytic oxidation and the use of good combustion practices/lean-burn technology.

An economic analysis was conducted as part of the top-down process to determine the cost per ton of CO removed while using catalytic oxidation. The cost to install and operate catalytic oxidation is estimated to be over $4,500 per ton of CO removed. This cost is considered to be high enough that the economic analysis does not justify installing catalytic oxidation to control CO for the proposed facility.

The resulting BACT level of control for CO, considering the use of good combustion practices, and supported by the permit application, is proposed to be set at 2.5 grams/hp-hour (30-day rolling average).

The RACT/BACT/LAER Clearinghouse was also consulted for similar operations to review required control technologies across the United States. The Clearinghouse indicated that the CO BACT determination for Hoosier Energy would be among the lowest for any existing engines found on the RACT/BACT/LAER Clearinghouse.

3. Volatile Organic Material (VOM)

The following VOM control technologies are analyzed for possible applicability to the proposed engines: good combustion practices/lean burn combustion, catalytic oxidation, post-combustion thermal oxidation, regenerative (or recuperative) thermal oxidation and nonselective catalytic reduction (NSCR).

These technologies' feasibility have already been addressed for CO and NOx, so will not be re-stated here (regenerative and recuperative thermal oxidations is a post-combustion thermal oxidation).

No ranking of technologies was necessary, since the only feasible and economically viable technology was the use of good combustion practices/lean-burn technology to reduce VOM emissions. The resulting BACT level of control for VOM, considering the use of good combustion practices, and supported by the permit application, is proposed to be set at 0.71 grams/hp-hour (30-day rolling average).

The RACT/BACT/LAER Clearinghouse was also consulted for similar operations to review required control technologies across the United States. The Clearinghouse indicated that the VOM BACT determination for Hoosier Energy would be higher than other entries found on the RACT/BACT/LAER Clearinghouse. This is a consequence of formaldehyde (a VOM) emissions, which have generally been ignored from LFG-fired engines.

4. Particulate Matter (PM)

Emissions occur as a result of carryover of dust in the flue gas. Options for control of filterable and condensable particulate include proper maintenance, good combustion practices, fuel treatment and add-on controls (e.g., filtration/baghouses), electrostatic precipitation, scrubbing).

Potentially Available Technologies

Regarding proper maintenance, airborne solid particulates are emitted as products of incomplete combustion. The degree or intensity to which these particles obstruct the transmission of light in comparison to a background is “opacity”, which is caused by PM in the exhaust gas. Properly operated engines will not result in visual emissions or opacity. However, engine problems resulting from lubricating oil entering the combustion chamber can result in visual emissions. Similarly, inefficient operation of the engine can result in products of incomplete combustion often expressed as visual emissions. Proper maintenance and design is the most effective method of preventing opacity from all types of internal combustion engines. The proposed engines and associated electronic control system are designed to meet the opacity standards. Proper maintenance is the most effective method of preventing opacity (and therefore PM) from the engines and is considered technically feasible.

Good Combustion Practice. The primary constituent of smoke is agglomerated carbon particles formed in regions of the combustion mixtures that are oxygen deficient. Optimization of the combustion chamber designs and operation practices that improve the oxidation process and minimize incomplete combustion is the primary mechanism available for lowering PM_{10} emissions. Good combustion practices/lean burn combustion is a technology that is built into the engine whereby the air/fuel (A/F) ratio is controlled as to minimize the formation of NOx and CO, encourage complete combustion, the complete oxidation of carbon to CO_2 and in the case of PM_{10}, reduce the emissions of products of incomplete combustion. The system used on the Jenbacher engines is called the LEANOX Lean Mixture Combustion Control. The LEANOX system is synonymous with good combustion practices/lean burn combustion. This practice is technologically feasible for the facility because it has been installed and operation on numerous engines throughout the United States.

Fuel Treatment. The LFG can be treated to remove moisture and condensable impurities and then reheated to ensure that the gas supplied to the engines is above the dew point temperature. Coalescing filters can be used to remove particulates and moisture.

Add-on Controls

Fabric filters

Fabric filters, or baghouses, use filtration to separate dust particles from dusty gases. They are one of the most efficient types of dust collection available, and the most effective collectors can achieve a nominal collection efficiency of more than 99 per cent for fine particulate matter ($PM_{2.5}$).

Electrostatic precipitators (ESP)

ESPs control particulate emissions through electrical forces. They can achieve high control efficiencies of 99 per cent or more. The most important aspect for control efficiency for an ESP is its size, which allows for higher residence time, which increases the likelihood that each particle will be collected.

Scrubbers

Scrubbers control particulate emissions through the capture of particles within droplets of water, which is sprayed into the exhaust stream as a mist, but agglomerates into larger and larger droplets. Removal of the droplets and particulates from the gas stream typically requires a mechanically aided separator and/or a mist eliminator, achieving a control efficiency of from 80 per cent up to 99 percent.

In general, add-on controls such as particulate fabric filters can capture exhaust gas particulates and prevent them from being released into the atmosphere. However, the high temperatures of the exhaust (approximately 850^{o}F) are greater than the acceptable operating temperatures for fabric filters. Additionally, a portion of the particulate matter that is emitted from engines is condensable which means they are not formed until after they enter the atmosphere. Fabric filters can only capture solid particulate and would not reduce condensable particulate matter emissions. Similarly, the RBLC database indicates no available add-on controls for PM_{10} were identified for LFG-fired IC engines. Add-on controls are not considered to be technically feasible for LFG-fired IC engines.

The BACT limit for filterable PM, considering the use of good combustion practices, source variability, and supported by the permit application, is proposed to be set at 0.1 grams/hp-hour, 30-day average.

The RACT/BACT/LAER Clearinghouse was also consulted for similar operations to review required control technologies for other landfill engines across the United States. The information in the Clearinghouse indicates that the proposed BACT determinations for $PM/PM_{10}/PM_{2.5}$ (total) and PM (filterable) for the proposed engines would be among the lowest rates relative to all types of similar engines addressed by the Clearinghouse.

Startup, Shutdown and Malfunction (SSM)

The control technology selected for the engines does not necessitate consideration of alternative BACT limits for startup and shutdown. Accordingly, the numerical BACT limits for the engines would apply at all times. The required work practices for startup, shutdown and malfunction are intended to assure that appropriate measures are taken to minimize emissions from startup, shutdown and malfunction. For this purpose, the draft permit establishes certain basic measures that must be used to minimize emissions. It also establishes a general approach to minimize emissions through formal operating and maintenance procedures, which may be refined based on actual operating experience at the facility.

Attachment 2 – BACT Discussion for Siloxane System Regeneration

Introduction -

Hoosier has chosen to install a siloxane removal system that would enable the facility to process treated LFG to remove siloxanes from the gas before the LFG is used as fuel at the facility. The siloxane system would have at least at least two absorption vessels. The treated LFG will flow through one absorption vessel while the other vessel is off-line. The absorption vessel would contain a sorbent that removes siloxanes from the LFG. The LFG would be processed by passing it through one of the vessels. The other vessel would be off-line, either awaiting regeneration, being regenerated, or awaiting return to active operation. In the regeneration cycle, the vessel would be heated electrically and ambient air blown through the vessel. This drives the adsorbed siloxane compounds from the sorbent, generating an off-gas stream.

Process Design -

An alternative approach to addressing siloxane in the LFG would be to simply feed the treated LFG directly to the engines. The siloxanes in the gas would be combusted in the engines. The gradual build up a coating of silica on the cylinders would make this approach problematic for consistent operation of the facility so was not included as part of Hoosier’s design for the project.

Control of Off-Gas (VOM Emissions) -

To address the off-gas from the regeneration as it contains VOM, the following possible alternatives were considered[5]: disposal of spent sorbent material without regeneration, routing of the off-gas into the engine intake, catalytic oxidation, regenerative/ recuperative thermal oxidizer (RTO) and direct thermal oxidization.

Offsite disposal of the sorbent without regeneration would involve opening the absorption vessels each day and disposing of the spent sorbent. This option is not technologically feasible because the absorption vessels are not designed to be opened frequently.

Routing the off-gas into the engine intake is not technically feasible. The engines must maintain a relatively constant inflow of air/fuel to operate efficiently. Large changes in inflow that would be caused by routing the off-gas to the engines would cause problems with engine operation. The purpose of the siloxane removal system is to remove siloxane from LFG prior to combustion in the engine. Routing the off-gas to the engine would defeat the purpose of the siloxane system.

Catalytic Oxidation is typically used when the off-gas stream has sufficient heat content or fuel value that the conversion of VOM to CO_2 can be facilitated with a catalyst. This option is not technically feasible because the off-gas stream temperature varies considerably during the regeneration cycle, initially being near ambient temperature. Given the nature of the off-gas, a catalyst cannot effectively operate at ambient temperature. The

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[5] Emitting off-gas directly to the atmosphere was rejected because it could present a safety issue.

siloxanes in the off-gas would also lead to a build-up of silica on the catalyst, causing it to fail.

An RTO operates in a similar manner as a thermal oxidizer, except that it is typically used when the volume of the gas stream supports the higher capital cost of a more fuel-efficient combustion technology. The off-gas from the regeneration process is relatively small, so as to not support use of an RTO. In addition, the intermittent nature of regeneration and the variation in VOM content of the off-gas stream during the regenerative cycle would be problematic as RTO’s function most reliably with consistent exhaust streams. In any case, thermal oxidizers can provide comparable performance as applied to this off-gas stream as compared to an RTO.

A thermal oxidizer would combust the VOM in the off-gas. Thermal oxidizers are commonly used for effective control of VOM emission streams. The thermal oxidizer’s destruction efficiency of 98% across the regeneration cycle is proposed as BACT for VOM control of off-gas with combustion. However, use of this control technology will have its own emissions as discussed below.

Control of Emissions Associated with Combustion of Fuel in the Oxidizer

CO, NOx, VOM and PM_{10}/$PM_{2.5,}$

The RBLC database does not contain entries for flares combusting LFG for NOx or CO. There are very few enclosed combustors in existence that are used to control siloxanes such as this one, therefore the information available to compare to is limited. Without anything to compare to, Hoosier presents the manufacturer’s emission rate guarantees, not to exceed the following as BACT:

- NOx 0.08 lb/mmBtu of heat input
- CO 0.2 lb/mmBtu of heat input