Evaluation of Gas Turbine Air Quality Impacts from a Community Perspective

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ABSTRACT

The recent deregulation of the utility industry and the simultaneous demand for additional electrical generating capacity has resulted in the construction of new gas turbine generation stations throughout the U.S. This has presented many communities with their first experience evaluating new electrical generating facilities. Like other states, Wisconsin has seen numerous turbine stations proposed by independent power producers as well as by more familiar utility companies. Some communities have rejected outright the construction of a new turbine station. Others have accepted the construction of new generating stations after extensive consideration of the economic and environmental impacts on the community. In the case study presented here, the Village of Pleasant Prairie evaluated the air pollution control permit application, draft permit and technical support documents provided by the Wisconsin Department of Natural Resources. Based on this review, the Village provided comments and suggestions to assure that the project minimized its air quality impacts on the community, utilized Best Available Control Technology to control its emissions, left room for economic growth in the area, and incorporated sufficient monitoring and reporting requirements to keep the Village updated on the facility air quality compliance status. The review of the proposed 1,050 combined cycle gas turbine generating station included a comparison with recent BACT determinations for similar turbine stations, an evaluation of the percentage of air quality increment to be consumed by the project, and an a modeling evaluation of the project. As a result of this review, the Village requested that the state agency incorporate the following additional requirements: emission offsets for the ozone nonattainment area were to be obtained from sources upwind of the project site; emission limitations were to be reduced to levels comparable to recently permitted turbine generating stations; emission limitations were to be lowered or stack heights increased to minimize the consumption of the air quality increment for PM_{10} and leave room for future industrial growth in the nearby industrial park; and, the Village was to receive copies of all pertinent testing, monitoring and compliance certification documents.

INTRODUCTION

The recent deregulation of the utility industry and the simultaneous demand for additional electrical generating capacity has resulted in the construction of new gas turbine generation stations throughout the U.S. This has presented many communities with their first experience evaluating new electrical generating facilities.

Like other states, Wisconsin has seen numerous gas turbine generating projects proposed by independent power producers as well as by more familiar utility companies. Some communities have rejected outright the construction of a new turbine station. Others have accepted the construction of new generating stations after consideration of the benefits and impacts it will have on the community. In the case study presented here, the Village of Pleasant Prairie evaluated the draft air quality construction permit and technical support documents provided by the Wisconsin Department of Natural Resources for a combined cycle gas turbine project in this community. Based on this review, the Village provided comments and suggestions to the WDNR to minimize project air quality impacts on the community.

RECENT GAS TURBINE PROJECTS

Table 1 summarizes 23 recent gas turbine projects in Wisconsin. The majority of these have been proposed during the last two years and have been developed by independent power producers rather than by established utilities in the state. They range in generation capacity from 25 to 1,080 megawatts (MW). Approximately 65% are simple cycle turbine projects; the remainder are combined cycle.

These projects require various regulatory approvals prior to construction. Air pollutant emissions from these projects are large enough to require issuance of an air pollution control permit from the Wisconsin Department of Natural Resources. New electrical generation capacity in the state must be approved by the Wisconsin Public Service Commission. Both of these regulatory approvals provide opportunities for public review and comment on the project design and impacts. In addition, any project with greater than 20 MW of capacity requires the preparation of a Environmental Impact Statement under the Wisconsin Environmental Policy Act before the agencies act on the proposal.

Table 1. Wisconsin Gas Turbine Projects

Site Name	Location	Capacity (MW)	Type	Approval Date
LS Power	Whitewater	170	Combined Cycle	1995
DePere Energy Center	DePere	180	Simple Cycle	1997
Rockdale Generating	Johnstown	350	Simple Cycle	Withdrawn
RockGen Energy Center	Christiana	525	Simple Cycle	1999
Manitowoc Public Utilities	Manitowoc	25	Simple Cycle	1999
WPS Corporation	Marinette	102	Simple Cycle	1999
Germantown Power Plant	Germantown	85	Simple Cycle	1999
Pleasant Prairie Power	Pleasant Prairie	85	Simple Cycle	Pending
Germantown Power Plant	Germantown	213	Simple Cycle	1999
SEI Wisconsin LLC	Neenah	360	Simple Cycle	1999
Kohler Peak Power	Kohler	60	Simple Cycle	Withdrawn
Badger Generating Station	Pleasant Prairie	1050	Combined Cycle	2000
Germantown Power Plant	Germantown	213	Simple Cycle	2000
Manitowoc Energy Service	Manitowoc	99	Simple Cycle	Pending
Elk Mound Station	Eau Claire	80	Simple Cycle	2000
Shoto Energy	Two Rivers	80	Simple Cycle	Pending
Appleton Coated	Combined Locks	48	Combined Cycle	Pending
Fox Energy - Kaukauna	Kaukauna	600	Combined Cycle	Pending
Fox Energy - Freedom	Freedom	600	Combined Cycle	Pending
Badger Generating Station	Pleasant Prairie	1080	Combined Cycle	Pending
SEI Wisconsin LLC	Plover	680	Both	Pending
New Berlin Energy Park	New Berlin	375	Simple Cycle	Pending
Badger Generating Station	Pleasant Prairie	1050	Combined Cycle	2000

Reference: 1

PROJECT DESCRIPTION

The Village of Pleasant Prairie is located in Kenosha County, in southeast Wisconsin between Chicago and Milwaukee. The Badger Generating Station, a 1,050 MW combined cycle gas turbine generating station, was proposed for construction just north of the Village corporate industrial park. This would be a merchant power plant, selling electricity wholesale. The electricity generated would be sufficient to supply the needs of 200,000 homes. It was proposed by PG&E Generating, a subsidiary of PG&E Corporation based in San Francisco. The gas turbine project site is shown in Figure 1.[2]

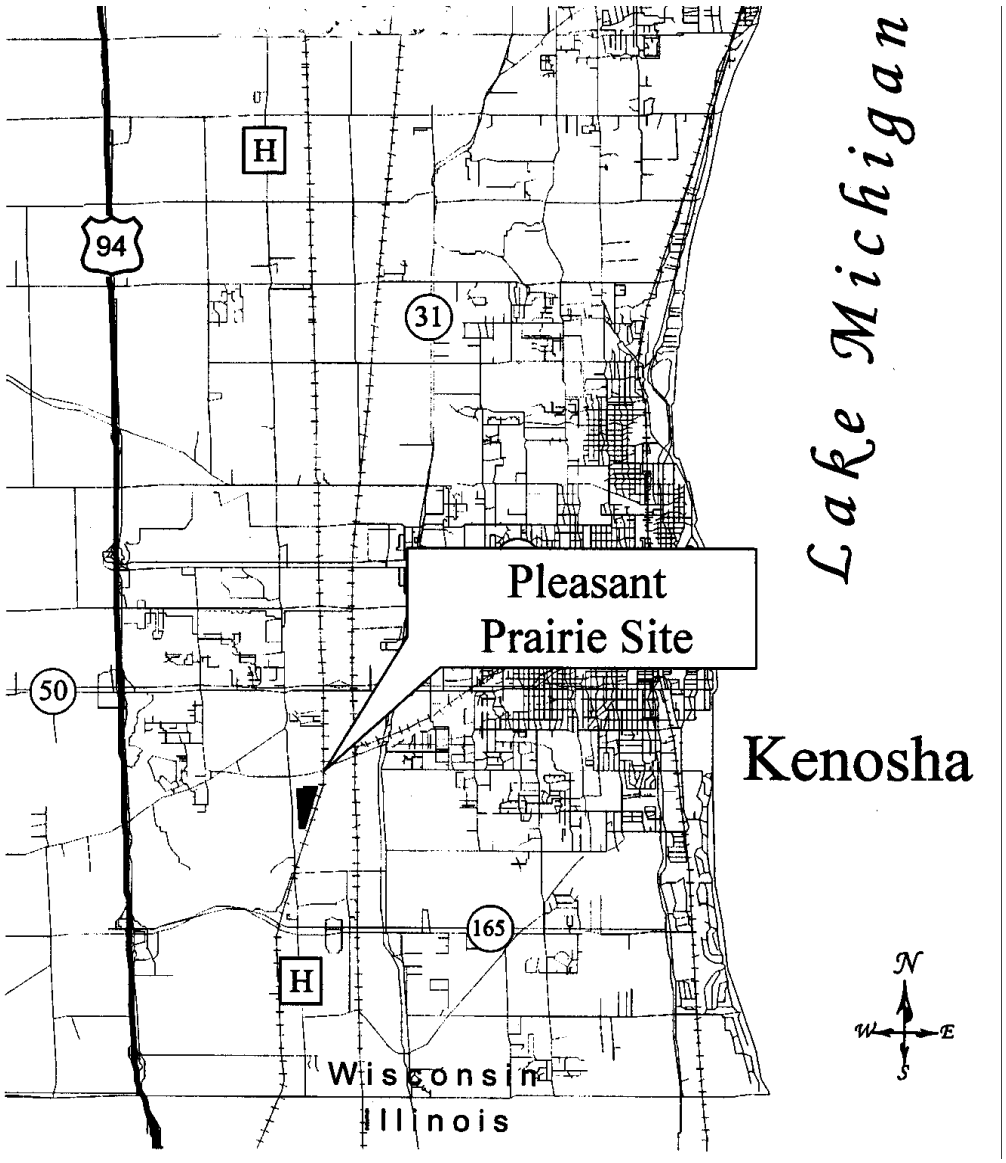

Figure 1

Village representatives evaluated the proposed Badger Generation Station to determine if the project was acceptable for their community. As part of this evaluation, the Village reviewed the air pollution control permit application, draft permit and technical support documents provided by the Wisconsin Department of Natural Resources.[3,4,5,6,7,8,9,10,11] The permit and supporting documents provided the proposed allowable air pollution discharges from the facility, anticipated emission control methods, and compliance demonstration procedures including stack tests, record keeping and monitoring. Based on its review, the Village provided comments and suggestions to the WDNR for improvements to the project to assure the project minimized its air quality impacts on the community.[12,13]

Approved emissions from this gas turbine project are summarized in Table 2.

Table 2. Gas Turbine Project Emissions

Air Pollutant	Approved Emissions (tons per year)
Nitrogen Oxides (NO_x)	522
Carbon Monoxide (CO)	1097
Volatile Organic Compounds (VOC)	62
Particulate Matter (PM)	543
Sulfur Dioxide (SO_2)	80
Sulfuric Acid (H_2SO_4)	49
Ammonia	478
Formaldehyde	51

Reference: 4

Projects which are issued air pollution control permits may also be subject to the Prevention of Significant Deterioration (PSD) regulations. The PSD requirements are applicable to larger sources of air pollution such as the turbine project. The PSD rules are specified under 40 CFR Part 51 and typically repeated in individual state regulations such as those of Wisconsin. Requirements of the PSD program are as follows:

- Use of Best Available Control Technology to control emissions;
- Compliance with air quality standards; and,
- Preconstruction ambient monitoring to determine existing air quality.

BEST AVAILABLE CONTROL TECHNOLOGY ANALYSIS

Project air pollution emissions must be controlled using Best Available Control Technology (BACT). This assures that project emissions are controlled using state of the art methods and technologies. A BACT analysis was prepared as part of the air pollution control permit application and reviewed by the WDNR. A proper BACT analysis will review the emission control equipment and methods used by similar projects; identify feasible options; and, choose the best methods based on performance, and economic, energy, and environmental costs. To minimize project emissions and impacts on the surrounding area, it is essential that the project incorporate state of the art in air pollution control methods. The proposed control methods and emission limitations are summarized in Table 3.

Table 3. Gas Turbine Air Pollution Control Methods and Limitations

Air Pollutant	Control Method	Emission Limitations
NO_x	Dry Low-NO_x Combustors Selective Catalytic Reduction	3.5 ppmdv @15% O_2
CO	Oxidation Catalyst	4.0 ppmdv @ 15% O_2
SO_2	0.003% sulfur in Natural Gas	4.5 lbs per hour per unit
PM	Natural Gas Fuel	30.5 lbs per hour per unit
VOC	Oxidation Catalyst	1.2 ppmdv @15 % O_2
H_2SO_4	Same as SO_2	2.8 per hour per unit
NH_3	None	10 ppmdv slip from SCR

Reference: 10

With a few minor exceptions, it was concluded that the emission control methods and emission limitations proposed for the project represented BACT for recently constructed combined cycle gas turbines. Recommendations were made to the WDNR for reducing the emission limitations of VOC and H_2SO_4 to those recently approved for a simple cycle turbine project approved for the RockGen Energy Center in the Town of Christiana, Wisconsin.[14] The WDNR concluded that these lower limitations were not applicable to the combined cycle project proposed for the Village.

ATTAINMENT AREA AIR QUALITY IMPACT ANALYSIS

The project was located in an attainment area which complies with the National Ambient Air Quality Standards (NAAQS) for most air pollutants. A modeling analysis was conducted as part of the permit application and WDNR regulatory review to assure that the project would not result in a violation of the NAAQS. For this analysis, impacts of the project are estimated and added to existing background air pollutant concentrations to assure they remain below the NAAQS. This analysis demonstrated compliance with the NAAQS. Results of this analysis are presented in Table 4.

Table 4. Gas Turbine Project NAAQS Compliance Analysis

Parameter	PM_{10}		SO_2			NO_x
Averaging Period	24-hour	Annual	3-hour	24-hour	Annual	Annual
Project Impact (ug/m^3)	48	7	338	129	15	12
Background (ug/m^3)	48	23	138	41	9	33
Total (ug/m^3)	96	30	476	170	24	45
NAAQS (ug/m^3)	150	50	1300	365	80	100
NAAQS Consumed (%)	64	60	37	47	29	45

Reference: 4

The NAAQS modeling analyses were reviewed to assure the assumptions and procedures followed standard USEPA and WDNR protocol.[15] From the supporting documents, it was not clear if the analysis addressed the variation in emissions, stack parameters and impacts at different gas turbine operating loads. It was recommended that the WDNR verify that this worst-case load analysis was conducted. After further review by the WDNR it was concluded that the worst-case load analysis had been conducted and the final results were found to be accurate and in compliance with the NAAQS.

In addition to the NAAQS, the permit application and WDNR review must assure that the project would not result in a violation of the PSD increments for PM_{10}, SO_2, and NO_x. The increments are typically more restrictive that the NAAQS and limit the air quality impacts of new industrial projects. Existing industrial sources or background air quality are not considered. Results of the increment analysis are presented in Table 5.

Table 5. Gas Turbine Project Increment Consumption Analysis

Parameter	PM_{10}		SO_2			NO_x
Averaging Period	24-hour	Annual	3-hour	24-hour	Annual	Annual
Project Impact (ug/m^3)	28	5	118	34	9	9
Increment (ug/m^3)	30	17	512	91	23	25
Increment Consumed (%)	95	27	23	38	43	35

Reference: 10

As with the NAAQS analsyis, the increment modeling analyses were reviewed to assure that the assumptions and procedures followed standard USEPA and WDNR protocol.[15] The procedures were correct and the results were found to be accurate. A unique concern of the Village was the proximity of the new gas turbine project to its industrial park located to the south. As shown in Table 5, the modeling results suggested that 95% of the available PM_{10} increment would be consumed by the project. If the gas turbine project consumed all of the available PSD increment, it would leave none for future growth in the industrial park. With this in mind, some states, such as Indiana, do not allow

projects to consume the remaining increment, but limit new projects to only a portion of the available increment.

A recommendation was made to change the project design to reduce its consumption of the available PSD increment for PM_{10}. This might take the form of lower PM_{10} emission limitations or improved dispersion by raising the gas turbine stacks from their proposed 120 feet height. With the issuance of the final permit, no changes were made to reduce the PM_{10} increment consumption. However, Badger Generating Company did apply for a new permit changing the facility design from four to three combustion turbines.[16] This new design raises the height of the turbine stacks from 120 to 150 feet reducing project PM_{10} impacts.

NONATTAINMENT AREA AIR QUALITY IMPACT ANALYSIS

The gas turbine project was located in Kenosha County. This county as well as the rest of southeast Wisconsin does not currently comply with the NAAQS for ozone. It is designated as a nonattainment air quality area. There are additional requirements for VOC emissions, which form ozone in the presence of sunlight, to assure that new sources of VOC emissions do not exacerbate the current air quality problems. To reduce impacts on the nonattainment area, the project incorporated the use of an oxidation catalyst to burn VOC in the gas turbine combustion by-products. The remaining emissions would be offset by the purchase of emission reduction credits on a 1.3:1 basis from other sources of VOC emissions in the area which have either shut down or reduced their emissions.

The project design anticipated the purchase of emission reduction credits from a business located approximately 25 miles north in Milwaukee.[10] Formation of excessive ozone concentrations occurred during the summer months when prevailing wind directions were from the south. To assure area residents would benefit from the emission offsets, it was recommended that the offsets be instead obtained from air pollution sources to the south and upwind of the project site. With the issuance of the final permit, no change was made to the location of the emission reduction credits. It was considered acceptable to obtain the credits anywhere in southeastern Wisconsin, and beyond WDNR regulatory authority to secure enforceable credits in Illinois, located just south of the project site.

PRECONSTRUCTION AMBIENT MONITORING

Under the PSD requirements, the gas turbine project was required to conduct preconstruction ambient monitoring for any air pollutants that were predicted via dispersion modeling to have air quality impacts above the PSD monitoring exemption thresholds. For this project, the maximum downwind PM_{10} concentrations were predicted to exceed its exemption threshold. The WDNR had proposed to waive the monitoring requirement. Existing monitors in adjacent Milwaukee and Waukesha Counties were considered adequate to provide suitable data to establish pre-project air quality conditions. In some instances, state agencies have required post-construction monitoring rather than delay a project by requiring one year of preconstruction monitoring.[17,18]

It was recommended that the WDNR not provide an exemption to the monitoring requirement for PM_{10}. In lieu of preconstruction monitoring, it was recommended that the WDNR require the project to conduct one year of post-construction monitoring. The information provided by this monitoring

would serve several purposes:

- Determine if the air quality near the generating plant is similar to the background concentrations assumed by the WDNR for its modeling analysis;

- Determine if the air surrounding the plant is attaining the air quality standards;

- Verify that project operations are not causing an exceedence of air quality standards; and,

- Provide background concentrations for use for future industrial development and air quality planning in the county.

When the final permit was issued, the WDNR did not require either pre-construction or post-construction ambient monitoring.

VERIFYING FUTURE COMPLIANCE

Emission limitations or air pollution control methods established in an air pollution control permit will also include methods for demonstrating compliance with these requirements. Examples of compliance demonstration requirements include the following:

- Stack tests;
- Record keeping;
- Monitoring emissions;
- Monitoring emission control system operating parameters;
- Malfunction reports; and,
- Annual emission inventory reports.

Copies of all reports are submitted to the regulatory agency for review, and are then available as public documents.

It was recommended that the draft permit be amended to require the facility to notify both the WDNR field office and the Village of Pleasant Prairie when a compliance report is submitted to the regulatory agency. This will assure that the Village remains informed of the air quality compliance status of the facility. The type of reports for which this requirement would apply included the following:

- Notification of planned stack tests;
- Construction progress reports;
- Requests for extension of the construction permit;
- Six-month monitoring reports;
- Annual compliance certifications;
- Compliance test results;
- Reporting of spills, malfunctions, or planned shutdown of air pollution control equipment;
- Annual emissions inventories and the subsequent inventory certification; and,
- Title V operation permit application for the facility.

The final permit did not incorporate the recommendation to provide copies of compliance reports to the Village. It was concluded by the WDNR staff that the agency did not have the regulatory authority to incorporate this requirement. The Village considered incorporating this requirement into its own contractual arrangements with the project.

ISSUANCE OF FINAL PERMIT

After consideration of comments on the draft permit and its supporting documents, the WDNR issued a final air pollution control permit for the Badger Generating Company 1,050 MW combined cycle gas turbine project in Pleasant Prairie, Wisconsin.[19] The permit did not incorporate any of the comments made on the draft permit by the Village of Pleasant Prairie. However, Badger Generating has reapplied for a new permit changing the design from four to three combustion turbines with a capacity of 1,080 MW.[16] This new design raises the height of the turbine stacks from 120 to 150 feet which will reduce project air quality impacts which was recommended for the earlier project.

CONCLUSIONS

The recent deregulation of the utility industry and the simultaneous demand for additional electrical generating capacity has resulted in the construction of new gas turbine generation stations throughout the U.S. This has presented many communities with their first experience evaluating new electrical generating facilities. Like other states, Wisconsin has seen numerous turbine stations proposed by independent power producers as well as by more familiar utility companies. Some communities have rejected outright the construction of a new turbine station. Others have accepted the construction of new generating stations after consideration of the benefits and impacts it will have on the community. Evaluation of the draft air pollution control permit and technical support documents provides an opportunity for a community to provide recommendations for improvements in the design and project analysis and to assure that a new gas turbine project is:

- Designed in compliance with air pollution control requirements;
- Correctly evaluated to verify it will not adversely affect air quality in the community; and,
- Incorporating adequate methods to assure future compliance with permit requirements.

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KEY WORDS

gas turbine, combined cycle, electricity, electrical generation, air pollution control permit, Prevention of Significant Deterioration, PSD, Best Available Control Technology, BACT, National Ambient Air Quality Standards, NAAQS, increment