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RE: Marshalltown Generating Station –Facility ID: 64-01-012

Dear Mr. Owen:

These comments are submitted on behalf of Sierra Club and its 600,000 members, including over 5,400 members in Iowa. The issues addressed below regarding Interstate Power and Light (IPL) Company's Draft Prevention of Significant Deterioration (PSD) Permit (Draft Permit for the Marshalltown Generating Station (Marshalltown), are based off of the February, 2014 Technical Support Document prepared by the Iowa Department of Natural Resources (IDNR), the draft permit, the application and other supporting materials in the record.

The Marshalltown project is proposed a 600 megawatt (MW) natural gas power plant comprised of two F-Class generating turbines with heat recovery steam generators (HRSG) and a steam turbine in a combined-cycle configuration. Marshalltown is subject to greenhouse gas (GHG) prevention of significant deterioration (PSD) regulations. New construction projects that are expected to emit at least 100,000 tpy of total GHGs on a CO_2e basis, or modifications at existing facilities that are expected to increase total GHG emissions by at least 75,000 tpy CO_2e, are subject to PSD permitting requirements. IPL estimates that Marshalltown will result in increased GHG emissions of 2,666,523 tons per year (tpy) of CO_2 (Application at 1-2). Marshalltown would emit GHGs at a rate far greater than 100,000 tpy CO_2e during this contemporaneous operation period; therefore, the project is subject to PSD review for all pollutants emitted in a significant amount.

1. IDNR Must Establish the GHG BACT Limit Based on the Most-Efficient, Lowest Polluting Turbine Design Technology.

IPL will install an undefined F-Class turbine to operate an unlimited number of hours each year (i.e. 8,760 hours). IDNR set an emission rate limit of 951 lb CO2/MWh (gross output). (TSD at p.4.) Neither IDNR nor IPL provided any justification or support for this limit. IPL only included a single table in Appendix C of its Application, with a footnote reference that "All emission factors from AP-42, Tables 3.1 - 2A plus a 20% degradation safety factor."[1] (Appendix C, page 12.) This appears to be a reference to EPA's Clearinghouse for Inventories and Emissions Factors for Large Stationary Diesel and All Stationary Dual-fuel Engines.[2] That EPA data is from April 2000. It is nearly 14-years old at this point in time, and it does not reflect the advancements in turbine efficiency made by natural gas units. IPL's rationale for its natural gas turbine efficiency therefore does not meet the requirement that the BACT analysis determine the maximum degree of reductions available from control technology.

The PSD permit must require Marshalltown to meet a GHG emission rate that is achievable by the most efficient units that are currently available, unless there is some basis for rejecting the most efficient units due to site specific economic or environmental adverse impacts. In this case, there is no discussion whatsoever as to any site-specific factors that would prevent IPL from installing the most efficient combined-cycle turbines available on the market. At a minimum, IDNR must therefore revise the GHG BACT limit to reflect the emissions reductions achievable by modern combined-cycle natural gas units.

The EPA data from AP-42 is not specific to a combined-cycle turbine and does not appear to account for the efficiencies provided by the HRSG configuration. IDNR also included a 20% "degradation factor" on top of the generic data provided by EPA for a natural gas combustion turbine. IDNR did not question the source or validity of either the underlying emission data from the 14-year old EPA publication, nor did they question the need for a 20% degradation factor.

a) IDNR Must Review Vendor Data to Ensure Maximum Energy Efficiency at Marshalltown.

IDNR must verify and correct IPL's CO2 emission data. F-Class turbines are far more efficient than listed by IPL. For example, GE now rates the 2x1 GE7FA CCGT at 58 percent efficiency, which equates to a heat rate of **5,889 Btu/kWh** (net).[3] The applicable BACT emission limit is therefore **763 lb CO_{2e} /MWh (net) on a "new and clean" ISO basis**.[4] Other 600 MW combined cycle turbines perform at similar or even better efficiencies. IDNR must apply these heat rates and emissions limits to Marshalltown because BACT requires the maximum degree to GHG controls.

Clean Air Act § 165(a)(4) requires Marshalltown to install the Best Available Control Technology (BACT), which is defined as "an emissions limitation … based on the maximum degree of reduction for each pollutant subject to regulation under the Act…" 42 USC 7479(3); 40 CFR 52.21(b)(12). Reducing GHG emissions is directly related to minimizing the quantity of

[1] In a separate footnote on the same page, IPL indicates that CO2 startup estimates are from emissions data
[2] http://www.epa.gov/ttn/chief/ap42/ch03/
[3] The heat rate is 3412.75 Btu/kWH divided by the efficiency. Vendor specifications indicate thermal efficiency of 58 percent. http://www.ge-energy.com/products_and_services/products/gas_turbines_heavy_duty/7fa_heavy_duty_gas_turbine.jsp
[4] See Table 1, *infra*.

fuel required to make electricity. The PSD provisions do not allow the permitting authority to select a higher emitting technology based on the applicant's preference of different turbine designs. The BACT requirement is defined as "the maximum degree of reduction for each pollutant." 42 USC 7479(3). Therefore, the top-down BACT analysis requires IDNR to select the lowest emitting technology as the basis for setting the BACT emission limit. In this case, IPL's own application should have resulted in IDNR selecting an emission limit that reflects the modern capabilities of a 2x1 F-Class frame, such as the GE 7FA as the basis for setting BACT.

The heat rate of the units is fundamental to determining BACT for GHGs. Energy efficiency is a critical component of the BACT analysis, particularly for GHGs. EPA's *PSD and Title V Permitting Guidance for Greenhouse Gases* is clear on this point: "Use of inherently lower-emitting technologies, including energy efficiency measures, represents an opportunity for GHG reductions in these BACT reviews."[5] The energy efficiency of a technology forms the base of the BACT determination. "Initially, in many instances energy efficient measures may serve as the foundation for a BACT analysis for GHGs, with add-on pollution control technology and other strategies added as they become more available."[6] In this case, in addition to considering add-on technologies such as carbon capture and sequestration (CCS), IDNR must first establish the BACT limit foundation by setting the limit based on the most energy efficient technology design. The applicant may not choose a less efficient design. "When a permit applicant proposes to construct a facility using a less efficient boiler design…a BACT analysis for this source should include more efficient options."[7]

EPA's *PSD and Title V Permitting Guidance for Greenhouse Gases* expressly addresses an example of energy efficiency at a coal plant:

> In general, a more energy efficient technology burns less fuel than a less energy efficient technology on a per unit of output basis. For example, coal-fired boilers operating at supercritical steam conditions consume approximately 5 percent less fuel per megawatt hour produced than boilers operating at subcritical steam conditions.[8]

The EPA guidance makes clear that energy efficiency must be considered in the BACT analysis. The NSR Manual further provides: "The reviewing authority…specifies an emissions limitation for the source that reflects the **maximum degree** of reduction achievable…" (NSR Manual, p.B.2 (emphasis added)). Without a showing that the most efficient design is either technically infeasible or that it should be eliminated due to disproportionate site-specific energy, economic or environmental impacts, IDNR must set the GHG BACT emission rate limit based on the most efficient turbine design.

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[5] *PSD and Title V Permitting Guidance for Greenhouse Gases*, March 2011, p.29.
[6] *Id.*
[7] *Id.*
[8] *PSD and Title V Permitting Guidance for Greenhouse Gases*, March 2011, p.21 (citing: U.S. Department of Energy, Cost and Performance Baseline for Fossil Energy Plants - Volume 1: Bituminous Coal and Natural Gas to Electricity, DOE/NETL-2007/1281, Final Report, Revision 1 (August 2007) at 6 (finding that the absolute efficiency difference between supercritical and subcritical boilers is 2.3 percent (39.1 percent compared to 36.8 percent), which is equivalent to a 5.9 percent reduction in fuel use), available at http://www.netl.doe.gov/energyanalyses/pubs/Bituminous%20Baseline_Final%20Report.pdf).

In this case, IDNR must set the GHG emission limit and the heat rate limits based on the most energy efficient turbine design. The baseline for that limit is the GE 7FA heat rate of **5,889 Btu/kWh** (net) in ISO conditions. Any adjustments above that limit, such as compliance margins or efficiency losses from the ACC, must be clearly documented and fully supported in the record. Turbine vendors that can meet that limit are free to compete for IPL's business. This feature of the BACT program has been remarkably successful in encouraging development of more effective pollution controls for over 40 years.

b) IDNR Must Consider Additional Turbine Models in its BACT Analysis

IDNR's BACT analysis must consider the entire range of electric generation technologies that can meet this purpose. In this case, as discussed in more detail below, the applicable BACT emission limit for a modern, efficient combine-cycle natural gas is "new and clean" emission rate of 747 lb CO2/MWh (net).[9]

Generation of electricity by use of natural gas combustion turbine ("CT") and combined cycle ("NGCC" or "CCGT") technology has been common for decades and, indeed, represents the most likely choice for new fossil fuel-fired generation over the next several decades. BACT limits must reflect capabilities of high efficiency NGCC as for natural gas-fired stationary combustion turbines. However, IDNR's proposed limits do not reflect performance of the newest and most efficient NGCC designs available today or the new technologies –such as Fast Response NGCCs or Concentrated Solar Power (CSP)/CCGT hybrids that are now commercially available. IDNR offers no analysis that documents that its proposed limits reflect the performance of "high efficiency" NGCCs.

Over the past few years, there has been an across-the-board effort by turbine manufacturers to significantly increase the efficiency of gas turbine design under full and part-load conditions in both simple and combined cycle mode.[10] New, more efficient models and techniques such as the CSP/NGCC projects,[11] not reflected in the performance data relied on by EPA, have recently been introduced.

New high-efficiency products introduced in the past 5 years by major manufacturers such as General Electric, Siemens, Alstom, and Mitsubishi demonstrate the flexibility to support renewable generation, excellent part load performance and low GHG emissions. These include the GE, Alstom and Siemens designs specifically designed for daily load following and renewable support applications.

[9] In each case, small emission factors for CH_4 and N_2O should be incorporated. Sierra Club has also listed "net" emission rates which are more appropriate because the net rate properly accounts for the inherent efficiencies within a plant. Gross emission limits would not account for any on-site plant inefficiencies that may occur.

[10] See discussion in Gas Turbine World, 2012 GTW Handbook, pp. 6 -24.

[11] CSP can and has been retrofit to existing CCGTs, most notably the the Martin Next Generation Solar Energy Center, where 75 MW of CSP capacity was added to an existing 3,750 MW natural gas-fired plant. The approved and permitted, but not yet constructed Palmdale hybrid has 570 MW of CCGT capacity and 50 MW of CSP capacity. The PSD permit limit for this unit is 774 lb C02/MWh (net).

Table 1 – Available Turbines

NGCC Designation	Turbine Designation	Year	Plant Capacity (MW)	Efficiency (LHV)	Heat rate Btu/kWh
GE Heavy Duty 107 FA	1x7FA.04	2008	277	57.4	5948
GE Heavy Duty 207FA	2x7FA.04	2008	600	57.9	5889
GE Heavy Duty 107 FA	1x7FA.05	2009	320	57.7	6235
GE Heavy Duty 207FA	2x7FA.05	2009	648	58.5	6152
Mitsubishi MPCP1(M501J)	1xM501GAC	2011	404	59.2	5763
Mitsubishi MPCP2(M501J)	2xM501GAC	2011	811	59.4	5744
Mitsubishi MPCP1(M701J)	1xM701J	2011	470	61.5	5549
Mitsubishi MPCP2(M701J)	2xM701J	2011	943	61.7	5531
Siemens SCC-750x1	1xSGT-750	2012	47	51.7	6599
Siemens SCC6-8000H1S	1xSGT6-8000H	2010	410	60.0	5687
Siemens SCC6-8000H 1x2	2xSGT6-8000H	2010	820	60.0	5687

The average heat rate for these new NGCC offerings is 5,734 Btu/MWh. This results in a "new and clean" emission rate of 747 lb CO2/MWh (net). This is far below IPL's proposed limit of 951 lb CO2/MWh (gross), even if IDNR includes a generous compliance margin. The turbines listed above are "modern," available today, and provide a far better indication of NGCC technology that is both technically and economically feasible compared to IPL's proposed limit.

IDNR's BACT limit is further skewed because it calculates the limit based on gross output rather than net output. Net emission rates are more appropriate because they account for all of the pollution emitted from the turbines, whereas gross emission rates do not account for energy that is used on-site. This means that the actual GHG emissions at Marshalltown will be significantly higher than the permitted limits. IDNR should set BACT limits based on net emission rates.

2. IPL's Adjustments for Degradation Are Not Supported

The Draft Permit's BACT limits include a combined 20 percent compliance margin for degradation. (Application, Appendix C at p.12.) This compliance margin is excessive. Sierra Club agrees that some correction to design data could be necessary to address certain operational variables if it is justified by record evidence. However, IPL's proposed corrections in the application here are not supported by information in the record and are either overly large or entirely unwarranted. Finally, the Gas Turbine World Handbook points out that the performance specifications are conservative and that better performance is possible – as much as a 1.5 percent gain in overall plant efficiency – for higher, but none the less reasonable, costs.[12]

[12] 2012 GTW Handbook, p. 64.

a) No Support for Performance Margin Drop-Off

Degradation is an important factor to be considered, as the heat rate of the facility may gradually deteriorate slightly between overhauls. However, IDNR's estimate of 20 percent is far too high. Our own review of the literature indicates that 6 percent is a significant overestimate given maintenance practices that are widely used and known to improve output (and revenue). Even 3 percent is likely to be too high for newly designed and constructed units that employ efficient designs.[13] Published industry information asserts that good maintenance practices, including frequent offline water washing, reduce both the amount of performance degradation and the rate of performance degradation. Detailed testing by Siemens and other manufacturers demonstrates that with advanced cleaning systems, degradation in performance between major overhauls due to compressor fouling can be reduced to negligible levels of less than one percent. One such test shows a reduction in turbine efficiency from 35.3 percent to just 35.2 percent in over 47,000 hours of operation.[14]

If IDNR includes a degradation factor, then it must justify that factor. At a minimum, this means that IDNR needs to consider far more detailed information, such as CAMD data referenced in Table 2 below, than it has to date and ascertain the extent to which top-performing units – including units with better initial designs and units that employ appropriate maintenance practices –experience the assigned degradation factor. IDNR must make a record demonstrating that a degradation factor is necessary and that the degradation factor used in the permit appropriately represents the reasonable and unavoidable degradation of the facility.

b) IDNR Should Consider Actual Reported Emissions Data

Rather than relying solely on vendor estimates, IDNR should also analyze the achievable BACT limit based on available data from turbine designs that have been in operation. The following table includes reported emissions rates for efficient CCGTs.

[13] *See*, e.g., I.S. Diakunchak, Performance Deterioration in Industrial Gas Turbines, Journal of Engineering for Gas Turbines and Power, v. 114, April 1992, pp. 161-168 (1%); S. Can Gulen and Sal Paolucci, Real-time On-line Performance Diagnostics of Heavy-duty Industrial-gas Turbines, Transactions of the ASME (2%), Available at: http://www.thermoflow.com/WALK_GTEYE/ASME_2000-GT-312_ThermoflowGTEYE.pdf; J. Petek and P. Hamilton, Performance Monitoring for Gas Turbines, Orbit, v. 25, no. 1, 2005; Emerson Process Management, Gas Turbine Engine Performance, January 2005.

[14] Leusden, C, Sorgenfrey, C and Dummel, L *Performance Benefits Using Siemens Advanced Compressor Cleaning Systems*, ASME Paper 2003-GT-38184, Journal of Engineering for Gas Turbines and Power, pp 763-769 Vol 126, Oct, 2004 (available at: http://www.scribd.com/doc/76381599/compressor-washing).

Table 2. In-use Emission Rates for Low Emitting CCGTs[15]

Unit	Capacity (MW)	Average CO_2 emission rate - lb/ MWh (gross)	Highest reported CO_2 emission rate - lb/ MWh (gross)
TVA Lagoon Creek 1, TN	275	731	742
TVA Lagoon Creek 2, TN	275	757	774
Caithness LI Energy Center	330	795	812
Harry Allen Unit 5, NV	500	798	804
Harry Allen Unit 6, NV	500	797	803
Jack McDonough, GA[16]	840	802	802

The Lagoon Creek Plant employs the Mitsubishi 501F turbines in a 2x1 configurations. In 2009, this technology was rated at 57.3 percent efficiency and a heat rate of 5,955 Btu/kWh. The Harry Allen plant employs an earlier version of the GE Frame 7 configuration and reported gross emission rates of 803-804 lb CO_2e/MWh.[17] The Jack McDonough plant uses 3 Mitsubishi CCGTs in a 2x2x1 configuration, each of which is based on the M501G turbine. The M501G turbine is also available in a 2x1 configuration with a capacity of 800 MW. The McDonough gross emission rate converts to 826 lb/MWh (net).

Sierra Club also looked at CAMD data for all units in 2012. The compiled the data in Table 3 below shows the performance of both NGCC and CT units in 2012 that operated more than 4000 hours. All emission rates are in lb CO2/MWh, and data show gross, net and a 3 percent compliance margin (where applicable) over net generation.

Table 3 – 2012 CAMD Data for 4000+ Hours of Operation:

2012 Emission rate (lb/MWh) - key statistics	CT/CCGT > 4000 hrs gross/net/3%compliance (average operating hours)
average of all units	995/1025
median	879/905/932
average of top 10 percent	767/790/814
90th percentile unit	800/824/849
average of top 20 percent	789/813/837
80th percentile unit	818/843/868
average of bottom 10 percent	1466
average of bottom 10-20th percent	1303

[15] Data from CAMD CEMS Annual Data, as of May 3, 2012
[16] http://www.mhi.co.jp/en/news/story/200801161212.html
[17] https://www.nvenergy.com/company/energytopics/images/Harry_Allen_Fact_Sheet.pdf

The average of the top 10 percent of units that operated more than 4,000 hours annually (i.e. at or below the expected load profile of Marshalltown), including a 3 percent compliance margin, is 814 lbs CO2/MWh. This means that within the existing fleet today, 10 percent of the units are already performing far better than the proposed limit for the brand new Marshalltown unit. BACT is intended to reflect advancements in technology. The proposed limit of 951 lbs/MWh (gross) is far below the emission rates that are achievable by modern combined-cycle natural gas units.

3. IDNR Must Consider Other BACT Limits

IDNR compared the proposed Marshalltown BACT limits to several other BACT limits established for other combined cycle/heat recovery steam generating units.[18] Several additional recent PSD permits or draft permits also warrant review.

- The Palmdale Hybrid Power Project has a permitted GHG BACT limit of 774 lb CO_2/MWh.[19]
- The Pioneer Valley Energy Center (PVEC) similarly has a much lower permitted GHG BACT limit. The initial GHG limit is 825 lb CO_2/MWh, and the rolling average limit is 895 lb/CO_2 MWh.[20]
- The Louisiana Energy and Power Authority (LEPA) has issued a draft permit for the 84 MW Morgan City combined cycle facility with a GHG emission rate of 844.79 lb CO2/MWh (net).[21]

The limits are far below Marshalltown's permitted rate of 951 lb CO_2/MWh. BACT requires a limit based on the maximum degree of reduction achievable by pollution controls, which in this case results from the most efficient turbine designs. There are no site-specific reasons explaining why Marshalltown cannot meet the lower limits established in numerous other BACT permits. IDNR cannot justify a GHG limit that is objectively higher than other BACT limits without a detailed site-specific analysis explaining why it is infeasible for Marshalltown to meet the lower limits. The Clean Air Act requires the maximum limit achievable.

4. Solar Thermal Auxiliary Preheat Must be Considered in the BACT Analysis

The Palmdale Hybrid Power Project identified above included a 2-on-1 combined-cycle configuration with two GE 7FA gas turbines and one steam turbine producing a nominal electrical output of 563 megawatts (MW), of which up to 50 MW is produced from a solar thermal collection field.[22] This project used the solar thermal auxiliary, in combination with the HRSG, to power the steam generator. This hybrid configuration resulted in a much better source-wide GHG emission rate because solar thermal energy displaced some of the duct firing for the

[18] GHG Position Paper, pp. 6-10.
[19] http://www.epa.gov/region9/air/permit/r9-permits-issued.html
[20] http://epa.gov/region1/communities/pdf/PioneerValley/DraftPermit.pdf
[21] Morgan City Power Plant, Proposed Permit No. 2660-00316-V0. http://edms.deq.louisiana.gov/app/doc/queryresults.aspx
[22] Application for Prevention of Significant Deterioration Permit for Palmdale Hybrid Power Project, p.1-1 (available at: http://www.regulations.gov/#!documentDetail;D=IDNR-R09-OAR-2011-0560-0002).

steam turbine. EPA Region 9 determined that the source-wide GHG BACT limit was 774 lb CO_2/MWh.

Another similar hybrid facility, the Victorville 2 plant, is a 563 MW facility that achieves a thermal efficiency of 59.0 percent when using thermal solar hybrid technology to preheat water (steam) to provide a supplement to the combustion turbine exhaust that flows to a HRSG that feeds to the steam turbine. This configuration achieves a 6.3 percent gain in thermal efficiency compared to the Victorville 2 plant with duct burners.[23]

Several utilities in the United States are installing hybrid concentrated solar thermal technology to increase generation and increase efficiency of fossil fuel power plants. The concentrated solar provides a separate line of steam to the steam turbine to displace some of the fossil fuel requirements. Such systems can decrease fuel use and thereby decrease emissions by 10 percent in a combined cycle power plant.

Further efficiency gains are possible by using the solar hybrid technology in place of duct burning. The proposed Marshalltown plant's duct burning element significantly reduces the systems' overall efficiency. Duct burning is an inefficient method of generating a few additional units of power, compared to the many other options for generating the same incremental power. IDNR's BACT analysis did not consider the potential increase in efficiency achievable by using a solar hybrid design configuration in place of duct burners.

Use of solar hybrid technology to increase capacity in the steam turbine could provide similar generation capabilities as the proposed project without redefining the project and without sacrificing the load shaping capabilities of the facility. Given the greater efficiencies identified at the Palmdale and Victorville 2 facilities with the use of solar hybrid technology in lieu of duct burners, IDNR should include a solar hybrid configuration in its BACT analysis for Marshalltown. Absent site-specific considerations that preclude the use of solar hybrid technology, that technology should be the basis for the BACT emission limit.

Sierra Club appreciates the opportunity to provide these comments.

Sincerely,

*/s/ Travis Ritchie*____

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[23] *See*, Application for Prevention of Significant Deterioration Permit for Victorville 2 Hybrid Power Project (available at: http://www.regulations.gov/#!documentDetail;D=EPA-R09-OAR-2008-0406-0001).