FILED
July 9, 2024
INDIANA UTILITY
REGULATORY COMMISSION

Joint NIPSCO-CAC Exhibit 2

Witness Walter

NIPSCO's Public Responses to CAC Data Requests 1-15 (with Attachment A), 1-19, 1-20 (with Attachment A), 3-10, 5-5, 5-6, 11-1, and 17-2.

Cause No. 45947
Northern Indiana Public Service Company LLC's Objections and Responses to Citizens Action Coalition of Indiana, Inc.'s First Set of Data Requests

CAC Request 1-015:
Re: NIPSCO Exhibit 2 (Direct Testimony of Walter), page 9 lines 15-18. With regards to the "several other wind, solar, and storage projects that are in various stages of development but that will be in service by the time NIPSCO's coal-fired generation retires": (a) Please identify for each such project the type of resource, capacity in MW, current stage of development, and expected or estimated in-service date.
Objections:
Response:
Please see CAC Request 1-015 Attachment A which lists NIPSCO's current wind, solar and storage projects either recently placed in-service or in various stages of development.

Cause No. 45947
Northern Indiana Public Service Company LLC's
Supplemental Responses to
Citizens Action Coalition of Indiana, Inc.'s First Set of Data Requests

CAC Request 1-019:

Re: NIPSCO Exhibit 2 (Direct Testimony of Walter), page 21 lines 14-18. With regards to the expected operation of the CT Project:

(a) Identify the projected or expected annual capacity factor of the CT Project, and of each unit therein, for each of the years 2026 through 2050.

(b) Identify the projected or expected annual hours of operation of the CT Project, and of each unit therein, for each of the years 2026 through 2050.

Objections:

NIPSCO objects to this Request on the grounds and to the extent that this Request seeks information that is confidential, proprietary, and/or trade secret.

NIPSCO further objects to this Request on the separate and independent grounds and to the extent that this Request solicits an analysis, calculation, or compilation which has not already been performed and which NIPSCO objects to performing. As noted on page 3, lines 14-17 of Mr. Baacke's direct testimony (Pet. Exh. 3), the final size and make up of the CT Project is dependent on the results of the CT original equipment manufacturer ("OEM") bid event.

Response:

Subject to and without waiver of the foregoing general and specific objections, NIPSCO is providing the following response:

(a) NIPSCO's 2021 IRP and 2023 portfolio analysis developed capacity factor projections for gas peaker projects as a whole, and NIPSCO has not performed analysis for each individual unit within the proposed CT Project. See CAC Request 1-019 Confidential Attachment A for projections for the annual capacity factor of the gas peaker for 2026 through 2042, the fundamental dispatch modeling period NIPSCO analyzed for the 2023 portfolio analysis. Note that 2026 is a partial year, starting in June.

(b) NIPSCO's 2021 IRP and 2023 portfolio analysis developed operational projections for gas peaker projects as a whole, and NIPSCO has not performed analysis for each individual unit within the proposed CT Project. See CAC Request 1-019 Confidential Attachment A for projections for the annual operational hours for the gas peaker for 2026 through 2042, the fundamental dispatch modeling period NIPSCO analyzed for the 2023 portfolio analysis. Note that 2026 is a partial year, starting in June.

Supplemental Response:

See CAC Request 1-019 Confidential Attachment A-S for updated capacity factor information. NIPSCO notes that it has not performed any additional analysis as to the capacity factor for the CT Project but has deleted the figure for 2026 from the original CAC Request 1-019 Confidential Attachment A to note an in-service date that is one year later. Also note that 2027 is based upon a full year of modeling, but it is only expected to be in service for a partial year.

CAC Request 1-020:

Re: NIPSCO Exhibit 2 (Direct Testimony of Walter), page 28 footnote 13. With regards to the "extensive comments" that have been provided to EPA regarding the proposed GHG Rules.

(a) Identify and produce any comments submitted by NIPSCO or NiSource to EPA regarding the proposed GHG Rules.
(b) Identify the "slightly higher" Intermediate Load emission limits requested in the referenced "extensive comments."
(c) Identify the "latest, most-efficient design" that such "slightly higher" emission limits are "reflective of."
(d) Identify the capacity factor at which the CT Project would be able to operate if the "slightly higher" Intermediate Load emission limits are incorporated into the final GHG Rule.

Objections:

As to the part (d), NIPSCO objects to this Request on the grounds and to the extent that this Request solicits an analysis, calculation, or compilation which has not already been performed and which NIPSCO objects to performing.

Response:

Subject to and without waiver of the foregoing general and specific objections, NIPSCO is providing the following response:

(a) Neither NiSource, nor NIPSCO, submitted comments to EPA regarding the proposed GHG Rules. While neither NiSource nor NIPSCO is a member of the Gas Turbine Association (GTA), the GTA's comments are relevant to parts (b) and (c) below and are attached as CAC Request 1-020 Attachment A.
(b) The most extensive comments related to the performance capabilities and emission rates of natural gas combustion turbines were submitted by the GTA. For reasons described in their comments, the GTA "proposes a sliding scale of 1,300 to 1,700 lb CO_2/MWh, gross" to account for emission rate differences between larger and smaller turbines.
(c) As described in the comments submitted by GTA, "The levels as proposed will preclude a vast majority of the gas turbines used for intermediate operation to operate within the category." The higher emission limits proposed by the GTA

are expected to accommodate new simple cycle turbine design across various turbine sizes.

(d) See objection.

Cause No. 45947
Northern Indiana Public Service Company LLC's
Objections and Responses to
Citizens Action Coalition of Indiana, Inc.'s Third Set of Data Requests

CAC Request 3-010:

What steps has NIPSCO taken to move towards retirement of Schahfer 16A, 16B, 17 and 18? What additional steps does it anticipate taking?

Objections:

NIPSCO objects to this Request on the grounds and to the extent that this Request is vague and ambiguous as the term "steps" is undefined.

Response:

Subject to and without waiver of the foregoing general and specific objections, NIPSCO is providing the following response:

NIPSCO has added additional renewable electric generation assets to facilitate the retirements of Units 17 & 18, as well as the other coal units at R. M. Schahfer Generating Station. These assets include Rosewater Wind, Jordan Creek Wind, Indiana Crossroads Wind, Indiana Crossroads Solar and Dunn's Bridge I solar. NIPSCO has executed multiple projects to ensure the continued reliability of NIPSCO's transmission system once the operations of Units 17 & 18 cease. These Generation Strategy Transmission Upgrades projects include the Michigan City to Bosserman 138kV upgrade, Bosserman to County Line 138kV upgrade, Maple Substation to County Line 138kV upgrade, Maple to LNG 138kV upgrade, and LNG to Stillwell 138kV upgrade. Related to the retirements of Units 16 A & B, per the reliability study associated with the 2021 IRP filing, NIPSCO is moving forward with the filing of this CPCN to install new, more efficient, faster starting simple cycle combustion turbines with greater ramp rates. The 2021 IRP provided support for the addition of new combustions turbines as part of the retirement of Units 16A and 16B.

NIPSCO continues to communicate with employees relative to the retirement of the units at R. M. Schahfer Generating Station. The focus is on safety during this time of transition. There have also been communications with MISO. Attachment Y was originally filed with MISO in 2020 with a retirement date of 5/31/2023. Attachment Y was then modified in January of 2023 to change the retirement date to 12/31/2025 for Units 17 & 18.

CAC Request 5-005:

On October 13, 2023, the Midwest Alliance for Clean Hydrogen ("MachH2") announced it has been selected by the U.S. Department of Energy's ("DOE") Office of Clean Energy Demonstrations ("OCED") to develop a Regional Clean Hydrogen Hub ("H2Hub"). More information can be found here, where Nisource is listed as an alliance member: https://machh2.com/ With regard to MachH2, please answer the following as it relates to the project at issue in this proceeding:

(a) Is all or part of this project in the proceeding part of MachH2, or otherwise anticipated to benefit from MachH2 in the future, such as through the potential purchase of hydrogen from MachH2 partners for use as a fuel for the project in the future?

> (i) If yes, please describe in detail and provide any supporting documentation, including but not limited to any memorandums of understanding and executed agreements.
>
> (ii) If yes, please fully describe the Company's role in MachH2.
>
> (iii) If yes, is the Company seeking any tax credits or incentives? Please explain and provide supporting documentation.

(b) Does Nisource and/or the Company have any plans to be an offtaker of any hydrogen produced as part of MachH2?

> (i) If yes, please describe in detail and provide any supporting documentation, including but not limited to any memorandums of understanding and executed agreements.
>
> (ii) If yes, please describe and quantify hydrogen that NiSource and/or the Company has agreed to purchase from MachH2 partners by year for the next 20 years, any pricing terms that have been proposed or agreed to, and the method and fuel source by which the hydrogen will be produced.
>
> (iii) If no, please describe in detail NiSource's and/or the Company's role(s) as a member MachH2.
>
> (iv) Please provide an electronic copy of the MachH2 application and all attachments, worksheets / workpapers, exhibits, addendums, and amendments submitted by MachH2 to the U.S. Department of Energy's Office of Clean

Energy Demonstrations under Funding Opportunity Announcement, DEFOA-0002779.

(c) Does Nisource and/or the Company have any plans to produce any hydrogen for MachH2?

(i) If yes, please describe in detail and provide any supporting documentation, including but not limited to any memorandums of understanding and executed agreements.

(ii) If yes, please describe and identify the quantity of hydrogen that NiSource and/or the Company has agreed to produce as part of MachH2 by year for the next 20 years, any pricing terms that have been proposed or agreed to, and the method and fuel source by which the hydrogen will be produced.

Objections:

NIPSCO objects to this Request on the grounds and to the extent that it seeks production of information that is outside NIPSCO's and NiSource's custody and control.

NIPSCO further objects to this Request on the separate and independent grounds and to the extent that this Request seeks documents or information that are beyond the scope of this proceeding and are not relevant to the subject matter of this proceeding and are therefore not reasonably calculated to lead to the discovery of admissible evidence, as NiSource's participation or membership in MachH2 is not relevant to the proposed gas generation project presented in this proceeding.

Response:

Subject to and without waiver of the foregoing general and specific objections, NIPSCO is providing the following response:

a) No.
  i) Please see response to 1a.
  ii) Please see response to 1a.
  iii) Please see response to 1a.
b) No.
  i) Please see response to 1b.

ii) Please see response to 1b.

iii) NiSource is a member of the Midwest Alliance for Clean Hydrogen and participated, among a large and wide-ranging consortium of stakeholders (https://machh2.com/partnerships/). For more information please refer to the Midwest Alliance for Clean Hydrogen website which describes the common goals of the members of the Alliance (https://machh2.com/about-us/).

iv) See NIPSCO's objection. NiSource participated in the Midwest Alliance for Clean Hydrogen as a member. The application submitted to the U.S Department of Energy was submitted by the Midwest Alliance for Clean Hydrogen. Please see the Midwest Alliance for Clean Hydrogen press release dated April 10, 2023 at Midwest Alliance For Clean Hydrogen (MachH2) Submits Full Application to Department of Energy for Regional Clean Hydrogen Hub (H2Hub) - Midwest Alliance for Clean Hydrogen

c) No.

CAC Request 5-006:

Does the Company plan to produce or purchase any renewable natural gas product for the project at issue in this proceeding? Please describe in detail and provide any supporting documentation.

(a) If yes, please describe in detail and provide any supporting documentation.

(b) If yes, is the project able to run on 100% renewable natural gas, or is blending of another fuel required? Please describe in detail and provide any supporting documentation.

(c) If not, please state whether the Company has evaluated producing or purchasing any renewable gas product for the project at issue in this proceeding. If so, describe the results of such evaluation in detail, and provide any supporting documentation.

Objections:

NIPSCO objects to this Request on the grounds and to the extent that this Request solicits an analysis, calculation, or compilation which has not already been performed and which NIPSCO objects to performing.

Response:

Subject to and without waiver of the foregoing general and specific objections, NIPSCO is providing the following response:

NIPSCO has not contemplated the use of renewable natural gas ("RNG") or the purchase of RNG for use in this project. As a part of NIPSCO's overall fueling strategy for the project, the Company will review relevant sources of supply that support both the reliability and economic value of the CT Project.

Cause No. 45947
Northern Indiana Public Service Company LLC's
Objections and Responses to
Citizens Action Coalition of Indiana, Inc.'s Eleventh Set of Data Requests

CAC Request 11-001:

Please refer to the testimony of Witness Walter at page 29, lines 5-9 & 13-14: "NIPSCO currently projects capacity factors below 20%, except in the initial months of operation. During these initial months, based on the proposed GHG Rules, either the capacity factors must be limited to 20% or the CTs must achieve the Intermediate Load emission limitations [. . .] Based on the proposed Rules, NIPSCO fully expects the CT Project will comply."

a. Please explain whether in the initial months of operation NIPSCO expects the Proposed CT Project to comply with the GHG Rules by achieving the Intermediate Load emission limitations by emitting CO_2 under EPA's emission limits (in terms of tons per MWh) at times when the capacity factor exceeds 20%?

b. If not, please explain whether in the initial months of operation NIPSCO expects the Proposed CT Project to comply with the GHG Rules by limiting capacity factors below 20% at times when the 2023 Portfolio analysis would suggest running above 20% (as shown in CAC 1-019 Confidential Attachment A)?

Objections:

Response:

a. NIPSCO expects the aeroderivative units at full load operation to meet the proposed standard of 1,150 lb CO2/MWh (i.e., the Intermediate Load emission limitation prior to 2032) for operation above a capacity factor of 20%. For operation of the aeroderivative units at other load conditions, and for operation of the industrial frame unit across all operating conditions, the units are not expected to meet the proposed standard of 1,150 lb CO2/MWh. These expectations are subject to the results of the turbine equipment request for proposals and actual operating conditions of the units.

b. If the GHG Rules are finalized as proposed, and if the CT Project cannot meet the Intermediate Load emission limitation, then NIPSCO would comply by limiting capacity factors below 20%.

CAC Request 17-002:

With regards to the Michigan City plant:

a. Please explain whether the plant is under any obligation under the Effluent Guidelines ("ELG") Rule or Coal Combustion Residuals ("CCR") Rule to retire in 2028 (or any other date).
b. Please explain whether there are any ELG Rule or CCR Rule compliance costs that NIPSCO has or will be able to avoid by retiring the plant by the end of 2028.
c. Please explain whether there are any potential costs under the CCR legacy pond rule, 88 Fed. Reg. 31,982, assuming the rule is finalized as proposed in May 2023, that NIPSCO would be able to avoid by retiring the Michigan City plant by the end of 2028.

Objections:

NIPSCO objects to subpart (c) of this Request on the grounds and to the extent the Request calls for speculation.

Response:

Subject to and without waiver of the foregoing general and specific objections, NIPSCO is providing the following response:

a. No, the Michigan City Generating Station is not under any obligation under the Effluent Guidelines ("ELG") Rule or Coal Combustion Residuals ("CCR") Rule to retire in 2028 (or any other date).

b. There are no ELG Rule compliance costs that NIPSCO has or will be able to avoid by retiring the plant by the end of 2028. Regarding the CCR Rule, there would be avoided costs associated with the cessation of CCR material being generated and managed.

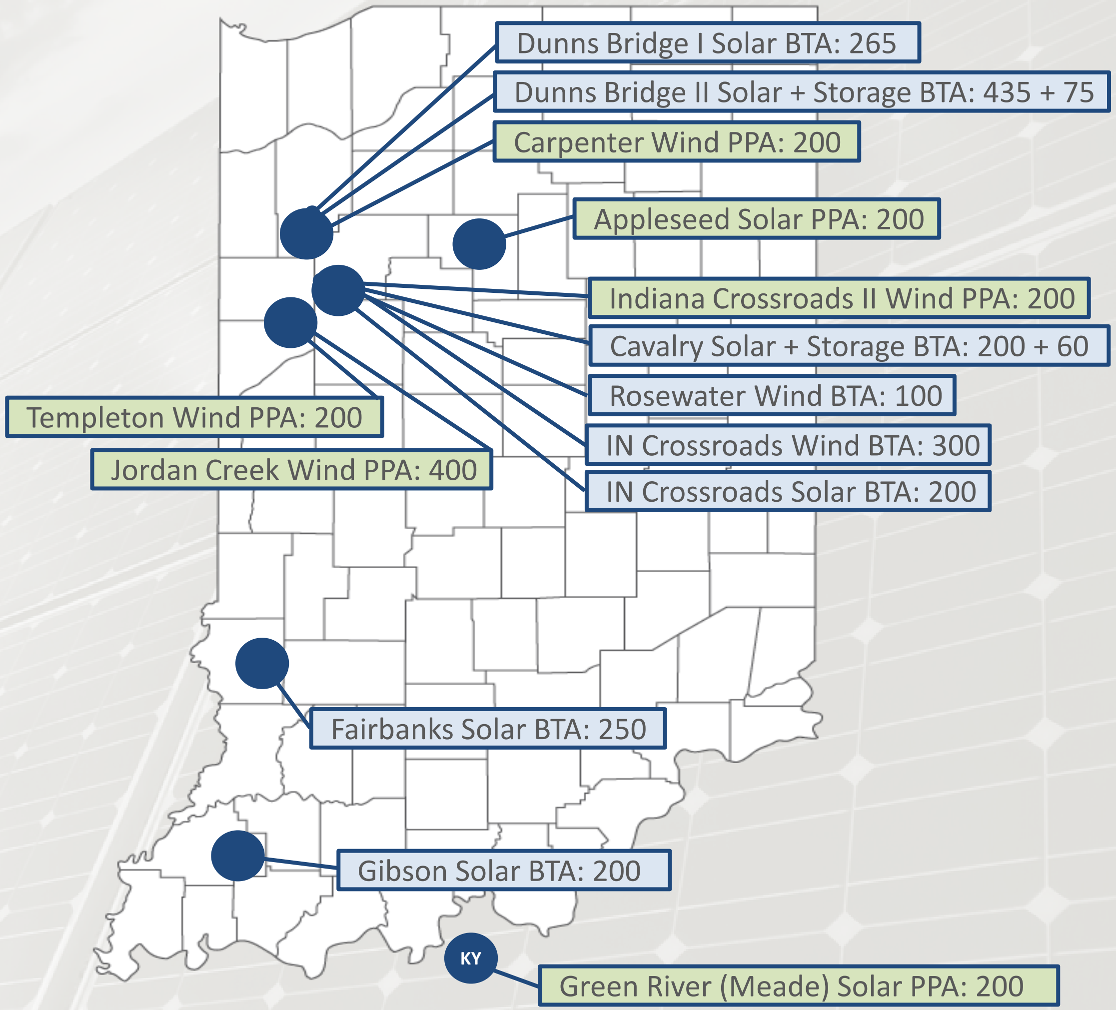
c. See objection. This question asks NIPSCO to speculate on a pending environmental rulemaking that has not been finalized.

Current Portfolio Update

🟦 BTA Project
🟩 PPA Project

BTA Projects	Installed Capacity (MW)	Estimated In Service	Status
Rosewater Wind	100	2020	Complete
Indiana Crossroads Wind	300	2021	Complete
Dunn's Bridge I Solar	265	2Q23	Complete
Crossroads Solar	200	2Q23	Complete
Transmission Projects	---	2Q23	Complete
Cavalry Solar + Storage	200 + 60	2Q24	Construction
Dunn's Bridge II Solar + Storage	435 + 75	4Q24	Construction
Fairbanks Solar	250	2Q25	Construction
Gibson Solar	200	2025	Filed with the IURC
Total			

PPA Projects	Installed Capacity (MW)	Estimated In Service	Status
Jordan Creek Wind	400	2020	Complete
Crossroads II Wind	200	2023	Construction
Templeton Wind	200	2025	Approved
Carpenter Wind	200	2025	Filed with the IURC
Appleseed Solar	200	2025	Approved
Green River Solar	200	2024	Amendment Approved



Dunns Bridge I Solar BTA: 265
Dunns Bridge II Solar + Storage BTA: 435 + 75
Carpenter Wind PPA: 200
Appleseed Solar PPA: 200
Indiana Crossroads II Wind PPA: 200
Cavalry Solar + Storage BTA: 200 + 60
Rosewater Wind BTA: 100
Templeton Wind PPA: 200
IN Crossroads Wind BTA: 300
Jordan Creek Wind PPA: 400
IN Crossroads Solar BTA: 200
Fairbanks Solar BTA: 250
Gibson Solar BTA: 200
Green River (Meade) Solar PPA: 200

Gas Turbine Association

Gas Turbine Association Comments to the EPA's Proposed New Source Performance Standards for Greenhouse Gas Emissions from New, Modified, and Reconstructed Fossil Fuel-Fired Electric Generating Units; Emission Guidelines for Greenhouse Gas Emissions from Existing Fossil Fuel-Fired Electric Generating Units; and Repeal of the Affordable Clean Energy Rule

The Gas Turbine Association (GTA) is a membership organization established in 1995 with a goal of communicating the message that gas turbines are, and will continue to be, a vital source of power generation in the United States of America and around the globe. The GTA is comprised of the major gas turbine manufacturers and service providers in the energy market, with U.S. gas power exports of $12 Billion (USD) per year, and more than 200,000 high paying jobs across the country. See Appendix B for a list of GTA membership.

Gas Turbine Association Mission and Membership

The GTA serves as the unified voice for the gas turbine industry. As the world transitions towards carbon neutrality, gas turbine technology will be essential for underpinning and securing a sustainable, clean, efficient, and reliable generation mix. Our mission, to educate and inform the public and U.S. policy decision makers regarding the value of gas turbine technology in the market, is of utmost importance to our country as gas turbines produce over one-third of our nation's electricity and power a substantial portion of our nation's pipeline infrastructure, representing an installed base of thousands of operating assets. Gas turbine technology attributes include but are not limited to the following:

- Variation in offerings from small to large gas turbines – making it suitable for an extraordinarily broad array of applications.
- Operational flexibility – that will provide power security to the growing renewable portfolio.
- Achieve a significantly lower environmental impact when compared to other fossil fuel energy technologies.
- Substantial gain in plant efficiencies in Combined Heat and Power applications.

Gas turbines are a cornerstone energy conversion technology, providing electricity and heat for industries and communities and are essential for ensuring the resiliency of the electricity grid. Gas turbine technology has evolved tremendously since the late 1970's, with an ever increasing focus on reducing greenhouse gas emissions; simply put, gas turbines are a critical part of the clean energy solution for today and for tomorrow.

The GTA appreciates the opportunity to comment on EPA's proposed GHG NSPS for EGUs.

Gas Turbine Association

Introduction

The United States Environmental Protection Agency (EPA) has proposed Greenhouse Gas (GHG) New Source Performance Standards (NSPS) for fossil fuel-fired Electric Generating Units (EGU) based on clean fuel combustion and highly efficient gas turbines, followed in future years by either increasing use of hydrogen as a co-fired fuel, or carbon capture and sequestration. EPA has proposed that these standards apply to three (3) subcategories of new, modified, and reconstructed EGU based on a unit's operating profile (capacity factor). The EPA has also proposed standards for one (1) category of existing unit, with request for comment on the inclusion of other categories. Furthermore, EPA has proposed implementation of these standards in three (3) phases, with increasing requirements to achieve the Best System of Emissions Reduction (BSER) and decreasing amounts of allowable CO_2 emissions. The GTA will offer comments and observations related to the proposed rules for new, modified, and reconstructed gas turbine EGU, and for existing gas turbine EGU as well. The GTA has no comments related to repeal of the Affordable Clean Energy Rule. The following paragraphs summarize GTA's understanding of what constitutes a subcategory, and the associated proposed BSER standards for the different Phases of implementation.

Low Load Subcategory: these include any unit that operates at less than a 20% annual capacity factor (e.g., 'peaking' units). For Phase-1, these units are required to burn clean fuels, with fuel emission factors ranging from 120 to 160 lb/MMBtu (HHV). There is no efficiency-based emission standard for this category. There are no proposed Phase-2 or Phase-3 BSER standards.

Intermediate Load Subcategory: these include any unit that operates above 20% capacity factor and less than a capacity factor based on the unit's rated design efficiency on an HHV basis. The proposed Phase-1 BSER CO_2 emission rate for these units is 1,150 lb CO_2/MWhr gross over a 12-operating month and a 3-year rolling average basis. Phase-2 (beginning in 2032) would require allowable CO_2 to 1,000 lb CO_2/MWhr gross over a 12-operating month and a 3-year rolling average basis, based on a BSER of combusting 30% by volume low-GHG hydrogen (H_2) blended with the natural gas fuel. There are no proposed Phase-3 BSER standards.

Baseload Subcategory: these include any unit which operates at a capacity factor greater than the unit rated efficiency on an HHV basis. The proposed Phase-1 BSER CO_2 emission rate for these units is 770 lb CO_2/MWhr gross over a 12-operating month and a 3-year rolling average basis (for EGU with a heat input greater than 2,000 MMBtu/hr, HHV and a sliding scale based on heat input for units with a heat input less than 2,000 MMBtu/hr, HHV). Phase-2 would require one of either two (2) pathways: (1) a decrease in the amount of allowable CO_2 to 680 lb CO_2/MWhr gross over a 12-operating month and a 3-year rolling average basis though combustion of 30% by volume low-GHG hydrogen (H_2) blended with the natural gas fuel (commencing in 2032); or (2) a decrease in the amount of allowable CO_2 to 90 lb CO_2/MWhr gross over a 12-operating month and a 3-year rolling average basis though 90% carbon capture and sequestration (CCS) (commencing in 2035). Phase-3 would only apply to those that chose to combust 30% by volume low-GHG H_2 in 2032 and would require a decrease in the amount of allowable CO_2 to 90 lb CO_2/MWhr gross over a 12-operating month and a 3-year rolling average basis though an increase in H_2 combustion to 96% by volume (commencing in 2038). There are no proposed Phase-3 BSER standards for those that chose the CCS pathway.

GTA Comments

The gas turbine industry represented by the GTA provides technology which supports the continued transition to clean electric generation technology. Gas turbines have provided reliable, dispatchable, flexible, affordable, and clean electric generation for decades and will continue to do so during the rapid transition to clean generation. The flexible operation of gas turbine technology is essential in this transition to enable the increased dispatch of renewable electrical assets. The GTA supports the transition to clean generation and EPA's efforts in that regard. However, there are provisions in this proposed rule that would constrain the flexible operation of gas turbine generating assets and could lead to reliability concerns and/or dispatch of less efficient, higher emitting technology, which is counter to the objectives of this rule. Overly restrictive regulation of the gas turbine industry will not lead to grid wide CO_2 emission reductions.

In addition, the GTA recommends that EPA consider cogeneration (combined heat and power, aka CHP) as a stand-alone category of gas turbine, separate from the Low, Intermediate and Base Load Subcategories, and for both new/modified/reconstructed and existing gas turbines. CHP facilities have different (and sometimes more) operational constraints and the steam generated is used for purposes other than electricity generation (e.g., district heating, manufacturing processes, etc.).

The GTA comments primarily focus on the Phase-1 efficiency-based emission standards, as these most directly impact the gas turbine equipment. The gas turbine industry, in the continuing transition to a cleaner electric grid, is developing the expanded capability to burn low GHG-emitting fuels, such as high-hydrogen blended fuels. However, the GTA does not agree that the EPA's proposed timeline is long enough to enable the build out of the necessary infrastructure to produce and transport the requisite volume of hydrogen to support the proposed standards. Similarly, the gas turbine industry is developing CCS solutions to enable necessary gas turbine generation while controlling CO_2 emissions. Again, there are concerns about the timeline to design and install carbon capture technology, and the availability of infrastructure to transport CO_2 to sequestration sites within the proposed timeline. The GTA provides limited comment to these aspects of the proposed rule.

Determination of Best System of Emission Reduction (BSER)

EPA has proposed the use of low-emitting fuels and Highly Efficient Gas Turbines as the Best System of Emission Reduction (BSER) for the Phase-1 emission limits. The GTA fully supports this BSER determination. However, the proposed emission standards and the basis by which the standards were established do not represent emission rates which are feasible by a majority of the gas turbine fleet. Appropriate standards are necessary to support the continued critical operation of highly efficient, reliable, and dispatchable gas turbine power on an often highly variable load basis, to support the continued energy transition to a cleaner electrical system. The GTA will provide detailed justification for this position later in these comments.

Adequate Demonstration of BSER

The EPA notes in section V.C.3 of the rule preamble, that emission standards must be based on a determination of the Best System of Emission Reduction which is “adequately demonstrated”, “taking into account” “cost … non-air quality health and environmental impact and energy requirements,”. EPA further notes the DC Circuit court determined the EPA may “hold the industry to a standard of improved design and operation advances, so long as there is substantial evidence that such improvements are feasible.”[1] In summarizing the case decision, the EPA has included a partial quote of this decision. That sentence taken from the DC Circuit court ruling continues by including the phrase, ***“ … and will produce the improved performance necessary to meet the standard” (emphasis added)***. While the GTA agrees with the Phase-1 BSER determinations for using low-emitting fuels and highly efficient gas turbines, the GTA does not agree that current state of the art gas turbines, which are already widely deployed, can achieve the proposed standards of 770 - 900 lb CO_2/MWh. Additional justification of this position will be provided in the following sections.

EPA’s Development of Emissions Standards

As stated in the rule preamble and supporting documentation, the EPA developed the proposed emission-based performance standards by evaluating recently operating plants (installed from 2015 to 2021), a comparison to gas turbine efficiency as referenced in the Gas Turbine World (GTW) performance document, and consideration of potential efficiency improvements that could be included on future gas turbines. The following sections comment to these evaluations.

General Comments to the Efficiency Standard

Gas turbine manufacturers, plant designers and the entire gas turbine industry are all strongly incentivized to produce highly efficient, and by association, lower CO_2 emitting units. The incentive for high efficiency is driven by delivering the most cost-effective power solution to our customers in an extremely competitive marketplace. Reduced fuel consumption and associated cost are the primary component in delivering a cost-effective power generation solution. A regulation that mandates an efficiency-based emission standards does not drive the industry to a higher technology solution or drive the unit operational mission to lower emitting solutions, but rather these mandates constrain and hinder the ability for gas turbine technology to provide reliable, affordable electricity.

The electricity generation industry is highly incentivized to design efficient plants to avoid fuel costs. This market incentive leads to the development and deployment of inherently low CO_2 emitting technologies. This regulation imposes emission limits and capacity standards that are mostly consistent with today’s market, but only for the units which operate at ideal conditions. Current or future units which are unable to meet the standard due to site conditions, or operate

---

[1] Sierra Club v. Costle, 657 F.2d 298, 364 (D.C. Cir. 1981).

under a more flexible, variable scheme (as dictated by grid requirements) will not be able to comply with the standard and, there are no available controls or mitigations available to the plant owner/operator that will enable compliance with the standard.

As the rule mandates that the existing and future fleet of gas turbines must operate within the industry economic drivers that are already in effect, we anticipate limited additional CO_2 reductions if this rule is promulgated as currently proposed. In other words, the units with the lowest cost of generation, which are the most efficient and lowest CO_2 emitting, are dispatched first. If these initially dispatched units are overly constrained, then the less efficient, higher emitting technologies will need to be dispatched. Bottom line: if the capacity limits and emission rates are overly restrictive, they will constrain the operational flexibility and thereby lead to higher grid wide CO_2 emissions.

Low Load Subcategory (Peaking) Gas Turbines

The GTA supports the clean fuel standard for the peaking gas turbine category. As EPA clearly demonstrates, and the GTA agrees, the operation of gas turbines in this category have highly variable operations and highly variable associated CO_2 emissions. The clean fuel standard is an appropriate regulation of this category. The GTA does however recommend revision to some of the details, summarized as follows.

- The capacity threshold for this category should be increased to at least 25%. The GTA agrees that most gas turbines, which function in a peaking category, operate at a 20% capacity factor or less. However, with the rapid and dynamic transition of the electrical generation economy, and the crucial need to ensure reliable availability of electricity, the unconstrained operating flexibility of these units is essential. Future grid demands may require some of the peaking turbines to operate at a higher capacity factor. Again, these turbines provide grid firming generation for reliable electricity generation. Constraining these essential generation assets could lead to capacity shortfalls, or the potential for less efficient or higher emitting energy resources to provide the necessary generation. Increasing the capacity to 25% will not change the way these gas turbines operate or increase total CO_2 emissions. Peaker capacities are already limited by grid dispatch economics, however if grid demands outweigh the dispatch economics a regulatory constraint will not result in lower emissions.

- The GTA agrees that no Phase-2 or Phase-3 emission requirements (e.g., H_2 blending or CCS) be applied to the Low Load gas turbine subcategory.

Evaluation of Simple Cycle Turbines for Low Load (Peaking) Capacity Gas Turbine Category

The EPA provided a comprehensive assessment of typical simple cycle gas turbine CO_2 emissions (lb/MWh) compared to both Capacity Factor (percent of generation vs potential generation over the entire year) and duty cycle (percent of generation vs potential generation during operating hours).[2]

Two graphs from the EPA Technical Support Document are duplicated below. The data in these graphs clearly demonstrate that CO_2 intensity (emissions in lb/MWh) is highly dependent on how a gas turbine operates, more so than the baseload emission rate of the gas turbine equipment. The low-capacity factor and low duty cycle units are, by definition, conducting frequent starts with limited hours of operation. As expected, the average CO_2 intensity for these units is much higher than the baseload emission and highly variable.

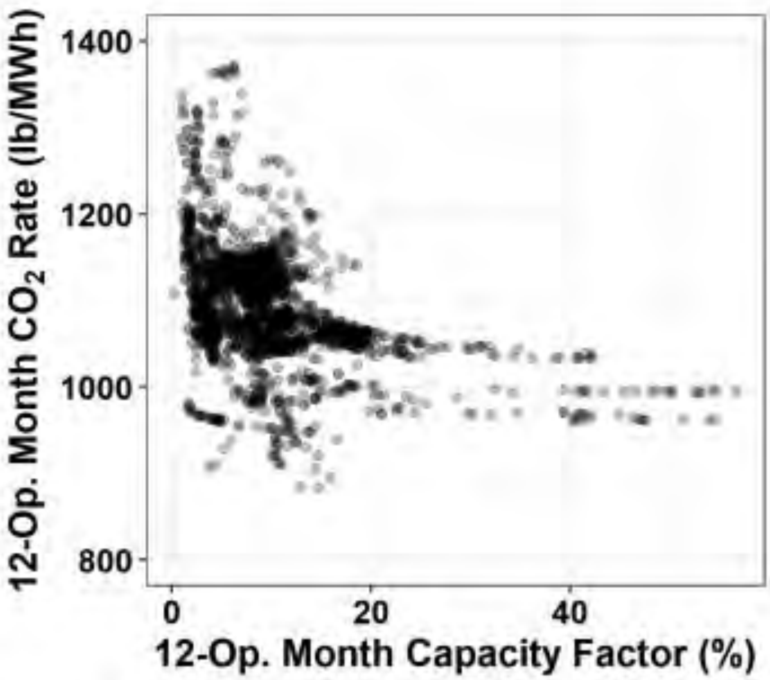


Figure 1. 12-Operating Month CO_2 Emission Rate (lb/MWh) versus 12-Operating Month Capacity Factor (%) for Select Better Performers. Source: EPA.

---

[2] Simple Cycle Stationary Combustion Turbine EGUs Technical Support Document

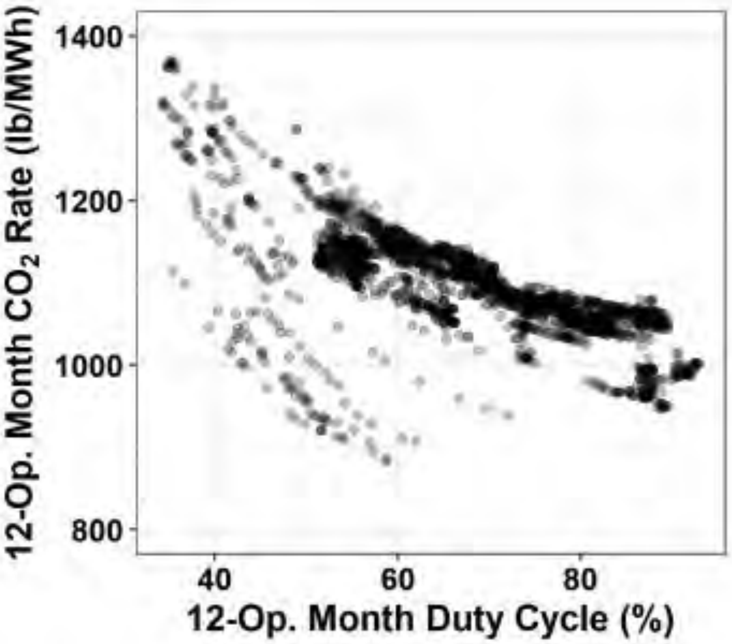


Figure 2. 12-Operating Month CO_2 Emission Rate (lb/MWh) versus 12-Operating Month Duty Cycle (%) for Select Better Performers. Source: EPA.

These graphs are included to clearly show the dependance on unit capacity factor and duty cycle on the annual emission rate. This same relationship exists for the Intermediate and Baseload gas turbine subcategories. EPA did not conduct a similar analysis for these categories of turbines.

Intermediate Load Subcategory Gas Turbines

The GTA does not agree with the proposed standard (emission rate) of 1,150 lb CO_2/MWhr gross for this subcategory and recommends a level of no less than 1,300 lb CO_2/MWhr gross. The rate proposed by EPA is only achievable by a few smaller high efficiency (aeroderivative) simple cycle gas turbines and large “G”, “H” or “J” class simple cycle gas turbines (which are too large to be appropriate for most peaking needs), operating at or close to gas turbine base (100%) load level (refer to Figure 3 below). The levels as proposed will preclude a vast majority of the gas turbines used for intermediate operation to operate within the category. Peaker plants throughout the U.S. fill a critical grid stability and reliability need and their value has only increased in recent years due to increased renewable generation. Only combined cycle plants would be able to operate in this intermediate category, and even in combined cycle, operation would be restricted to ~ 70% gas turbine load level and above for most of them. The standard as proposed will constrain virtually all simple cycle gas turbines to the peaking category with its currently proposed 20% capacity factory. This limit would prevent the gas turbine industry from providing the necessary flexible and variable generation to support electrical grid reliability requirements. Additional considerations follow.

- Larger gas turbines with higher operating pressures and temperatures can operate with greater overall efficiency. The GTW gas turbine fleet data clearly demonstrates the trend of higher emission rates from smaller turbines than larger turbines. To accommodate this reality, a sliding scale for smaller units is necessary for the Intermediate Load subcategory. EPA appropriately proposed a sliding scale requirement for smaller baseload units due to the Rankine cycle being less efficient for smaller Combined Cycle. This relationship also applies to the Intermediate Load subcategory. The GTA proposes a sliding scale of 1,300 to 1,700 lb CO_2/MWh, gross.

- The Intermediate Load Subcategory should more clearly specify the Phase I BSER as "Highly efficient ***simple or combined cycle*** [emphasis added] generation", as some of the Base Load (combined cycle) subcategory CT EGUs will choose to reduce their capacity factors and comply with the Intermediate Load Subcategory limits (as they cannot meet the Base Loads Subcategory limits).

- While gas turbines will be able to burn 30% H_2 blend fuel in the timeline proposed, there is serious concern enough low-GHG H_2 will be available, and whether the infrastructure will be adequately developed to support this proposed BSER. The GTA highly recommends that relief be provided to plant owners and operators that are simply unable to procure the necessary amount of H_2 fuel.

Gas Turbine World Performance Data

GTW publishes performance data and specifications for the fleet of turbines across all Original Equipment Manufacturers (OEMs). This data represents the best ideal performance achievable for each turbine model considering operation at baseload ISO conditions, with no inlet or exhaust loss, in a new and clean condition (i.e., with no degradation), and no commercial design margin applied. The GTW performance specifications are excellent for comparative study across various turbine models, but meaningful adjustments must be made to compare this performance to as-designed site-specific performance capabilities.

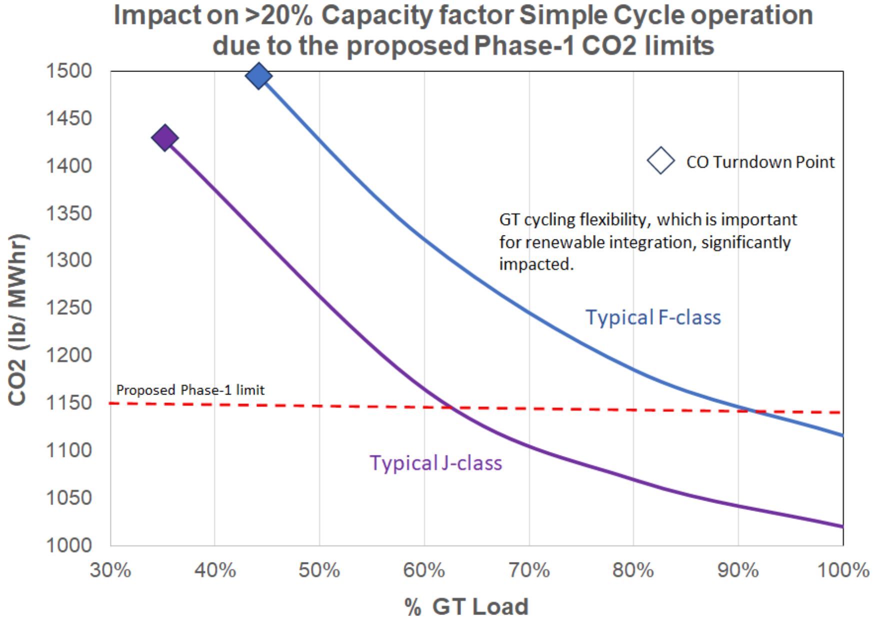


Figure 3. Simple Cycle Gas Turbine Load versus CO_2 Intensity

Gas Turbine Adjustments to Site Ratings (Simple Cycle)

Per GTW the following adjustments would apply to site specific conditions. These adjustments apply to the ideal baseload performance.

- **Ambient Temperature:** Gas turbines are more efficient on cold days than hot days. Operating profile versus site annual ambient temperature variations must be evaluated.
- **Site Elevation:** Higher elevation and associated lower air pressure results in lower output but does not significantly affect efficiency.
- **Inlet and Exhaust Pressure Losses:** Inlet systems include filters to remove ambient particulates, silencers, and inlet air conditioning systems. The exhaust system includes dampers and silencers. Both systems add pressure loss which decreases turbine output.
- **Degradation:** The quoted performance values are based on “new and clean” conditions with no degradation. All gas turbines experience a certain amount of degradation. The primary causes of degradation within the turbine include:
  - **Compressor fouling:** material buildup on the blade over time. High efficiency filters are included on the inlet, but despite these filters some debris will accumulate on the blades. This degradation can be partially recovered by online and offline water washes.
  - **Wear of blade seals:** there are seals between the end of the compressor and turbine blades to control air flow escaping around the end of the blades and not doing useful work. These seals wear over time. The grids demand for frequent fast starts can contribute to excess wear of these seals further degrading performance.
  - **Wear of other parts:** wear and fouling of compressor and turbine blades occur over time and can only be addressed during a major turbine overhaul.

Total heat rate degradation is generally in the range of 3 to 5% at the end of the interval between major overhauls.

Additional adjustments necessary to adjust to site specific conditions include:

- **Compliance Margin:** When GT OEMs warrant the performance of a new gas turbine there is commercial margin applied to that performance value. For any fleet of turbines there is variability from one turbine to another. To account for this variation, OEMs quote performance at a level within the range of fleet wide performance. The levels in GTW are most likely the median performance capability. This capability structure means half the turbines will do better than quoted and half will do worse. In the event of any shortfall, the customer is compensated through the payment of commercial liquidated damages. Additionally, when demonstrating the performance, there are agreed upon test tolerance and measurement uncertainty which is used to adjust the "as measured" performance.

  As previously noted, CO_2 is directly related to the gas turbine performance. The "as-measured" CO_2 is thereby subject to performance variations and test tolerance and measurement uncertainty. The EPA does not recognize or allow any commercial related margin or measurement uncertainty in their emission standards or reporting. Any CO_2 value which is defined in a permit limit or a warranty from a GT manufacturer must include margin to cover this range of uncertainty. The commercial uncertainty band is typically 5%.

- **Simple Cycle with SCR:** Current LAER (Lowest Achievable Emissions Rate) requirements in non-attainment zones dictate the need for a Selective Catalytic Reduction (SCR) system on Simple Cycle gas turbines to reduce NO_X. These SCR systems add significant backpressure and decrease plant performance. These systems also add significant auxiliary load reducing the net output. Any simple cycle gas turbine installation which requires an SCR system must consider the performance impact caused by the added backpressure. The influence of this equipment must be considered in establishing the standards.

Gas Turbine Adjustments to Site Ratings (Combined Cycle)

The GTW document also includes combined cycle ratings of various turbines. These ratings again are based on ideal performance conditions. In addition, the Rankine Steam cycle, as the EPA accurately notes, is sensitive to the steam turbine condenser temperature. Favorable assumptions are built into the GTW values. The adjustments noted above for simple cycle gas turbines all apply and in addition, the following adjustments apply to the combined cycle performance.

- **Steam Turbine Condenser Pressure:** Steam turbines convert high pressure steam into electrical energy. To improve performance, the steam is condensed at the back end of the turbine to create a vacuum. In effect the steam is pushed in the front of the turbine and sucked out the back. The larger the pressure difference, the more energy is produced at a higher efficiency. The steam turbine condenser is either water cooled, or air cooled.

The most efficient system is ‘once-through’ cooling in which water from a river, lake or ocean is drawn through the condenser. While EPA notes these are more efficient, no ‘once-through’ cooling condensers are envisioned to be permitted again considering the thermal impacts to the associated waterbody. The second most efficient system is a cooling tower in which the condenser water is dropped through a tower with fans drawing cooling air through the waterfall. With a cooling tower, water is lost through evaporative cooling. In arid locations, an air-cooled condenser is commonly used, in which air is blown over tubes to condense the steam. These systems are much more expensive and less efficient than ‘wet’ cooling towers but have the advantage of using much less water. Deployment of air-cooled condensers is becoming much more common, both in arid locations, and even in locations with adequate water supply, to simplify and shorten the permitting process.

- **HRSG Design:** As EPA accurately notes, 3-pressure Heat Recovery Steam Generators (HRSGs) and steam turbines with steam reheat, commonly referred to as 3-pressure reheat cycles, are often used for the largest and most efficient gas turbine combined cycle plants. For smaller gas turbines, the 2-pressure cycle is more common, some with reheat. For smaller gas turbines there is not enough exhaust energy to justify the additional cost and complexity of the addition steam pressure and/or reheat for the minimal additional improvement which may be available in the Rankine cycle. EPA notes the typical breakpoint for a 2-pressure to 3-pressure cycle is around 2,000 MMBtu/hr (HHV) of heat input. The GTA would clarify, while the difference between large plant design and smaller plant designs is accurate, the assessment of preferred steam cycle is conducted for every power plant design. Plant-specific requirements influence all design decisions and cause the exact break point to vary with each design.

Total Adjustment to GTW Performance

- A single value to account for the various margins identified above is difficult to assess. The exact magnitude of the correction will vary with turbine model and specific site conditions. The Russel City Energy Center located in California was the first facility to include a CO_2 value in their air permit. In this air permit an adjustment value of 13% was proposed and permitted to reflect the combined effects of variable operation, commercial margin, and degradation. This 13% margin was applied to the quoted unit performance, not the GTW performance. This value has been used often as a benchmark in site air permits. While various other methods have been applied to develop varying emission rates, the 13% adder seems a reasonable magnitude to adjust from quoted performance to an annual average.

  Since this 13% adjustment was added to the site-specific performance, additional margin is needed to adjust from GTW performance to a site specific annual average performance. An adjustment of 3 to 5% is typical when comparing GTW performance to site specific quoted values. In the following comments, a total adjustment of 15% was applied to compare GTW emissions to the real world annual average proposed emission rates.

Comparison of GTW performance to the Proposed Intermediate Standard

The EPA refers to the GTW performance of gas turbine models as a benchmark for the emission standards. The EPA also notes differences between GTW performance and real-life performance. The following sections highlight the key factors which must be considered to convert GTW performance to a value that can be used to assess a potential emission standard.

- Figure 4 depicts the CO_2 emission intensity as calculated based on the GTW quoted performance compared to gas turbine output. The red horizontal line represents the proposed emission standard for the Intermediate Subcategory of gas turbines. The green markers represent frame style units while the orange markers represent “highly efficient” gas turbine units. The “highly efficient” gas turbine units are assumed to represent aeroderivative turbine technology.

- As the name applies, aeroderivative turbines are gas turbine aircraft engines that have been repackaged to provide ground base generation. Aeroderivative turbines have the advantage of being the fastest starting units and tend to be more efficient than similar sized frame units. Aeroderivative units are designed for high reliability and low weight and tend to be more expensive.

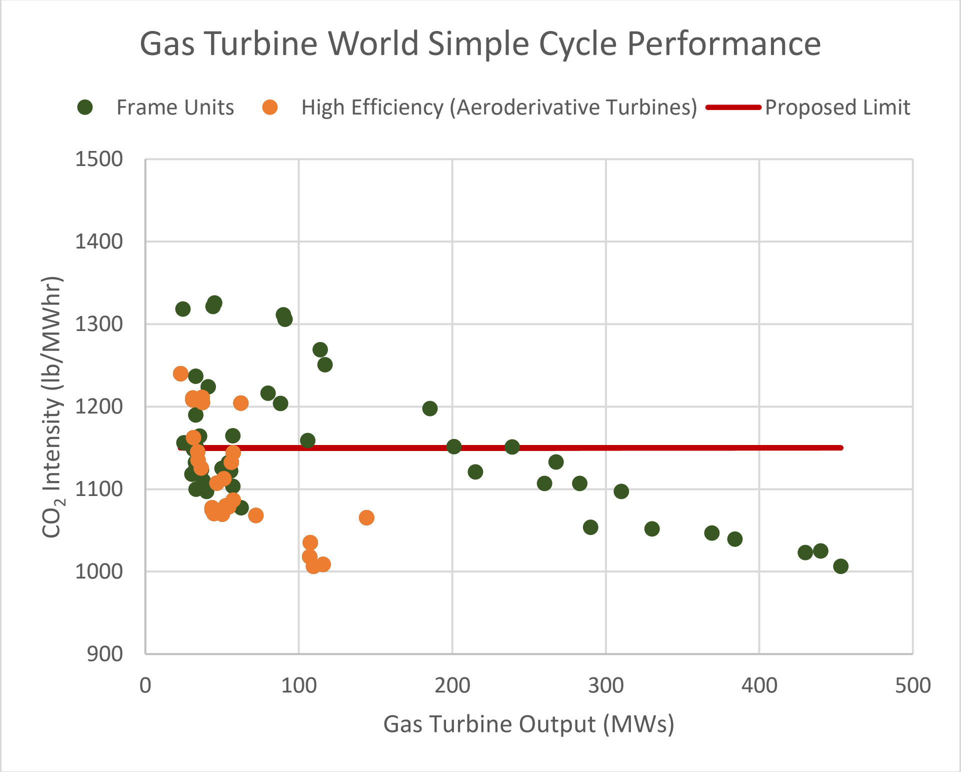


Figure 4. Gas Turbine World Gas Turbine (Simple Cycle) Performance

- Figure 5 represents the same fleet of turbines as Figure 4, with a 15% adjustment to simulate both the adjustment from GTW performance to site specific performance and reflect the 12-month rolling average of the proposed emission limit. With the 15% adjustment, a small number of turbine models can just achieve the proposed standard or are slightly above the proposed standard. Given the adjustment factor is an estimate to simulate the average fleetwide impact, some installations of these turbines, and as noted in EPA's fleet assessment, certain high performing turbines, can meet the standard. The GTA' s review of the existing fleet indicates approximately 15% of today's installed SC capacity can achieve the as-proposed standard.

- As previously stated in these comments, the resulting 12-month emission rate average is dictated far more by how the turbine is operated than the baseload efficiency of the unit. Also, as previous noted, the operating profile is dictated more by the grid requirements than by the plant owner or operator. It is not possible to warrant or accept a regulatory requirement that a majority of the fleet is not able to attain, has limited control over, and without technology available to assure compliance.

- Another key takeaway from these graphs is the clear demonstration that CO_2 intensity is inherently higher for smaller gas turbines than large gas turbines. This unimpeachable fact of gas turbine capability and performance highlights the need for a sliding scale for smaller units as the EPA has reasonably proposed for combined cycle units.

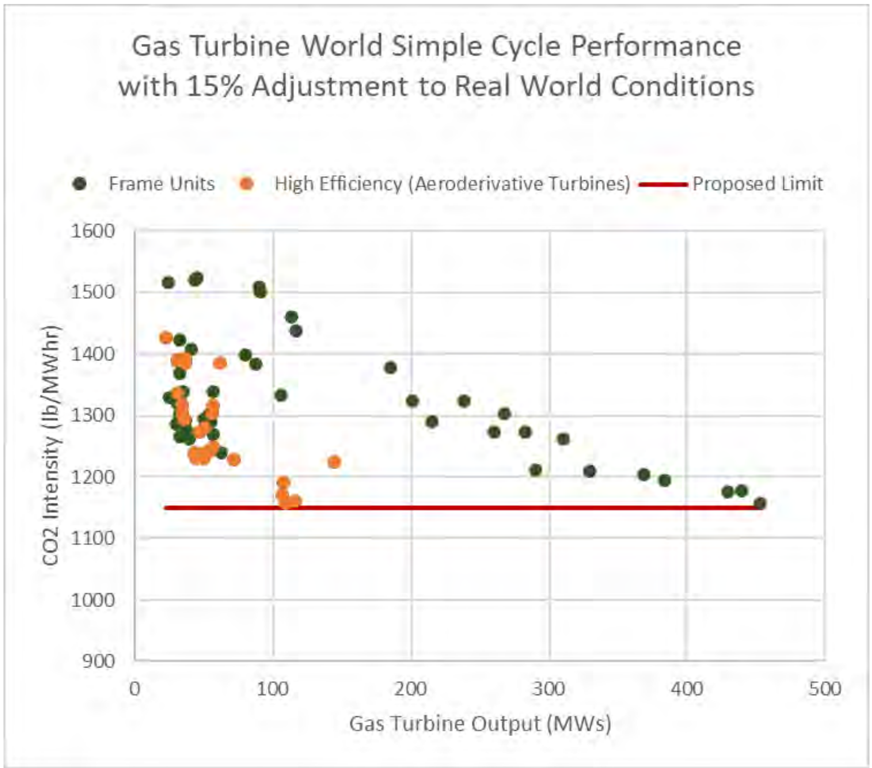


Figure 5. Gas Turbine World Gas Turbine (Simple Cycle) Performance with 15% Adjustment to Simulate Site Specific Performance and a 12-Month Rolling Average

- Figure 6 depicts the CO_2 emissions intensity as calculated based on the GTW quoted performance compared to combined cycle units. The red line represents the proposed emission standard for the Baseload Subcategory of gas turbines. This figure alone would appear to demonstrate that many turbine models could achieve the proposed standards when installed in combined cycle. Figure 7 depicts the same units with the 15% adjustment described in the previous section. This figure clearly shows that with this adjustment to simulate actual installation and operation, very few designs could meet the as-proposed standard.

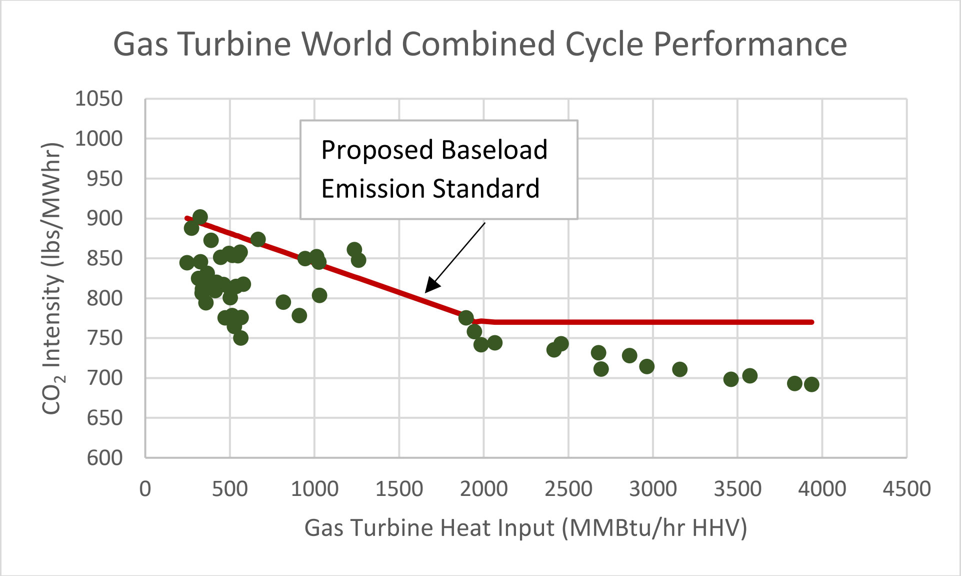


Figure 6. Gas Turbine World Combined Cycle Unit Performance

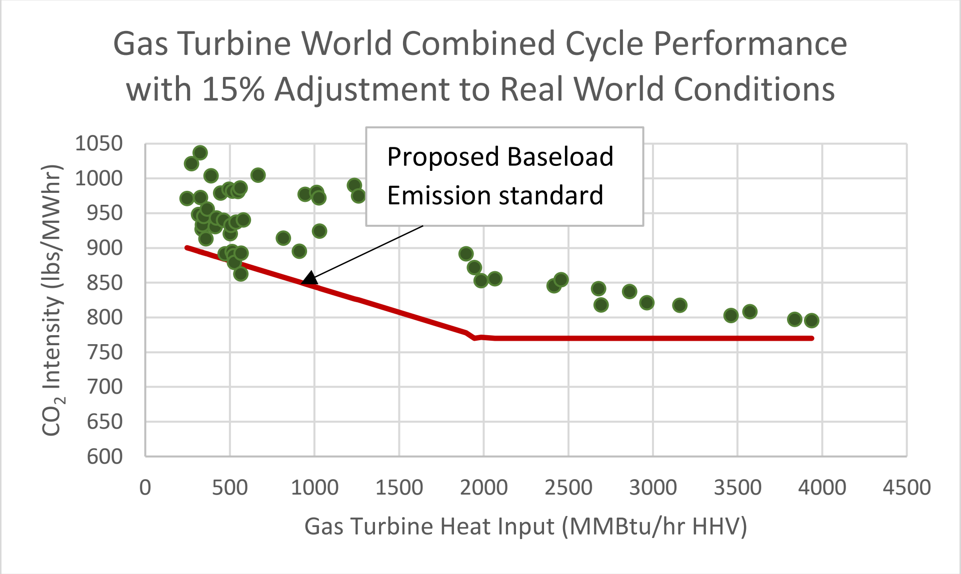


Figure 7. Gas Turbine World Combined Cycle Unit Performance with 15% Adjustment to Simulate Site Specific Performance and a 12-Month Rolling Average

- As seen in Figure 6, many turbine models would appear to satisfy the proposed emission standards, though as previously stated in these comments, the resulting 12-month emission rate average is dictated far more by how the turbine is operated than the baseload efficiency of the unit. Also, as previous noted, the operating profile is dictated more by the grid requirements than by the plant owner or operator. EPA identified that 14% of recently installed units can satisfy the proposed standard, and that would be expected considering the adjustment applied above will vary across the fleet of units with site conditions and operating profile. However, for the plants required to operate in less favorable environments in a variable manner there is simply no means to achieve the proposed standard. In addition, if 14% of units can meet the proposed standard, 86%, an overwhelming majority, cannot.

Baseload Turbines

The GTA does not agree with the proposed standard (emission rate) of 770 lb CO_2/MWhr gross for this subcategory and recommends a level of no less than 850 lb CO_2/MWhr gross. Further, the GTA recommends the point at which the CO_2 "sliding scale" for smaller units is applied begins at a heat consumption level of no lower than 2,500 MMBtu/hr, HHV. It is the GTA's view that an emission rate of 770 lb CO_2/MWhr gross does not represents a level consistent with BSER. As noted by EPA in the preamble, the DC District Court has ruled that EPA may "hold the industry to a standard of improved design and operation advances, so long as there is substantial evidence that such improvements are feasible." Though this ruling continues and states that in addition the improvements are feasible, the court states ***" … and will produce the***

improved performance necessary to meet the standard" (emphasis added). [3] The GTA disagrees that there are efficiency improvements available that will produce performance improvements necessary to meet the proposed standard.

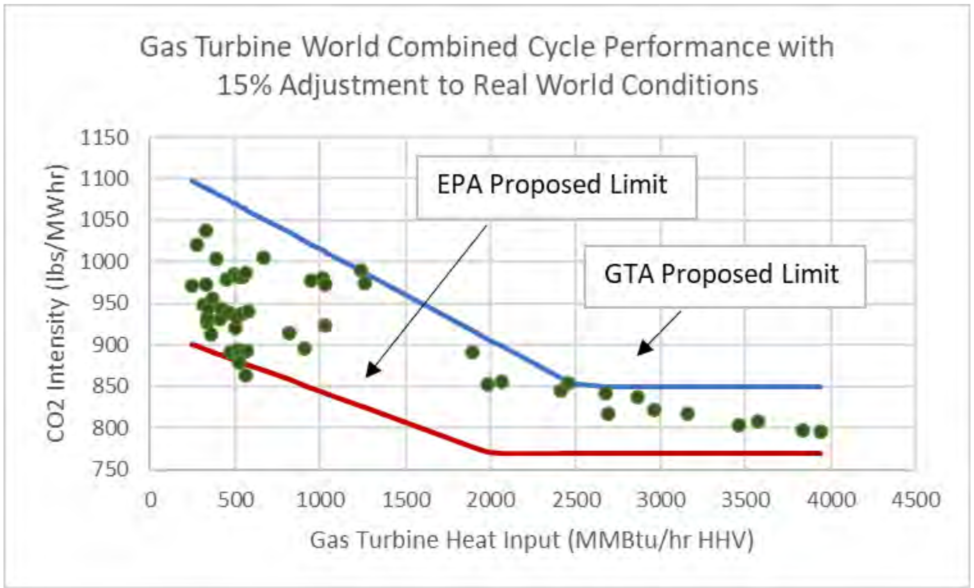


Figure 8. GTA Recommended Base Load Subcategory Emission Standard

As justification if this standard, EPA reviewed the performance of recently installed gas turbines and found that only 14% of these recently installed combined cycle plants can meet this standard. The remaining 86% of units are of substantially similar design. The GTA asserts there are no additional efficiency measures that could be applied to these or future units to "produce the improved performance necessary to meet the standard". Additional considerations follow.

- Gas turbine unit efficiency and CO_2 emissions intensity are impacted by site specific design conditions and by the operating mission dictated by the electric grid operators to support necessary electricity reliability. There are no sufficient improved performance options to be applied to these units to achieve the proposed emission standard.

- The proposed basis of a 12-operating month and 3-year rolling average for the CO_2 emission rate from a gas turbine facility is appropriate from a regulatory standard in that this accounts for all operating conditions including start-up, shutdown, part load operation, duct firing, backup fuel and degradation. However, gas turbine power plants run to satisfy grid demand and plant operators have little control over their operating profiles. When considering real-world variable operating requirements, which influence the 12-operating month average CO_2 emissions intensity much more than the baseload efficiency, there are

---

[3] Sierra Club v. Costle, 657 F.2d 298, 364 (D.C. Cir. 1981).

insufficient efficiency improvements within the plant owner/operators control to satisfy the proposed standard.

- A gas turbine unit that is challenged with compliance to the proposed standard would have to mitigate operation to reduce the 12-operating month CO_2 emissions intensity. The only means to lower the average CO_2 intensity is to operate at the unit at a baseload condition, the most efficient operating condition, for an extended period to reduce the 12-operating month average (refer to Figure 9). While this is the operating condition with the lowest CO_2 intensity, this is the operating condition with the highest CO_2 emission mass flow rate. There are no other means to reduce the average CO_2 emissions intensity. This sole mitigation option is both contrary to a combined cycle unit's mission to support grid requirements, and contrary to the intent of this rule to reduce overall CO_2 mass emissions. This comment applies to existing units as well.

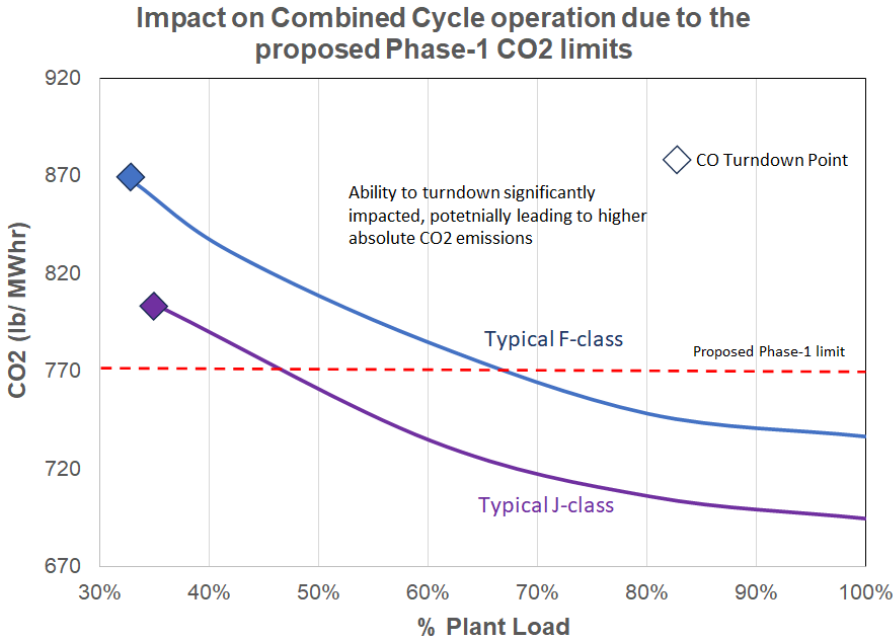


Figure 9. Combined Cycle Gas Turbine Load versus CO_2 Intensity

In Section VII. G. 1. of the Preamble, the EPA indicates the consideration of three different emission standards: 730, 770, and 800 lb CO_2/MWhr gross. In the evaluation of these values, the EPA notes that only a single unit, the Okeechobee Energy Center has demonstrated the ability to meet the 730 lb CO_2/MWhr emission standard. Furthermore, only 14% of recently installed combined cycle plants (installed between 2015 and 2021) have demonstrated the ability to meet 770 lb CO_2/MWhr, and 50% of recently installed combined cycle plants have demonstrated the ability to meet 800 lb CO_2/MWhr. Again, these standards are all proposed on a 12-operating month and 3-year rolling average basis.

Based on this review of recently installed combined cycle plants, EPA proposes a level of 770 lb CO_2/MWhr based on the flawed determination that there are performance improvements that could be installed on all future units to achieve this standard. This EPA determination assumes that because 14% of recently installed units can meet this standard, there are options available to enable all future units to achieve this standard, which is highly unrealistic. Key factors to consider follow.

- The EPA determination does not consider that an individual plant's 12-operating month average CO_2 intensity is driven far more by the plants operating profile than the base design efficiency of the plant. Plants are operated to meet grid demand requirements. The plant operator does not control grid operation. Many plants operate on Automatic Grid Control (AGC), meaning that once the plant is dispatched and operational, the plant load profile is driven by the grid operator, not the plant owner. As such, the plant owner has limited control over the plant's annual CO_2 intensity.

- Combustion Turbine plants that operate in hotter climates are typically less efficient than those in cooler climates and will therefore have higher CO_2 emissions intensities. EPA accurately notes that the steam turbine cooling technology has a significant impact on plant performance. Plants are more commonly using Air Cooled Condenser technology to reduce water consumption, especially in arid climates. The effort to reduce water consumption adversely impacts plant efficiency. This impact is most significant during hot ambient day operation.

- The base site conditions and the plant operating mission are outside of the plant operator's control, leaving no available options to reduce the plant's CO_2 intensity. There are simply no additional efficiency improvements that can magically reduce the CO_2 emissions from the remain 86% of combined cycle plants to "produce the improved performance necessary to meet the standard".

- Unlike a criteria pollutant such as NO_X, for which emissions controls can be built into the combustion system, or post-combustion controls can be added to the exhaust stream, the only way to reduce the CO_2 emissions from a unit (outside the Phase-2 and-3 controls of H_2 co-firing or CCS) is to improve the 12-operating month average efficiency. Again, there are simply no additional significant efficiency improvements available to magically meet the proposed standard, and the standards as proposed will not be achievable by a majority of the gas turbine fleet.

Figure 10 demonstrates the variation in emission rates when the plant is operated at different conditions. This specific plant includes two (2) "H" class gas turbines providing steam to one (1) steam turbine (aka, a 2x1 configuration) and an air-cooled condenser. As previously noted, the air-cooled condenser is a more expensive and less efficient option than other technologies but is often required due to water consumption restrictions.

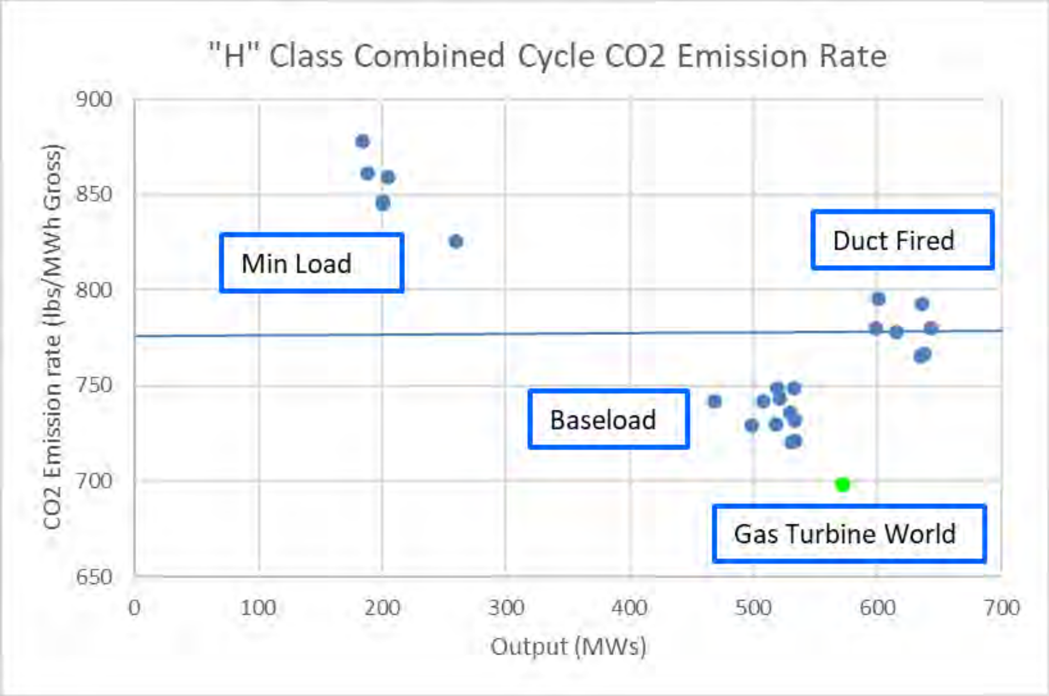


Figure 10. Calculated CO_2 Emission Intensity for a Combined Cycle Unit with Two "H" Gas Turbines Supplying Steam to One Steam Turbine with an Air-Cooled Condenser for Various Operating Conditions at New and Clean Conditions (no Degradation).

The green Gas Turbine World point represents the GTW performance level. The cluster of Baseload points represent the actual quoted performance for this specific site at various ambient temperature conditions. The design temperatures for this site range from -10 to 100°F. The baseload CO_2 emission rate for this configuration is approximately 5% higher than catalog rating, and ranges from roughly 725 to 750 lb CO_2/MWhr. The baseload CO_2 emission rate includes performance both with and without the benefit of inlet evaporative cooling applied on hot days. The Min Load points depict the CO_2 emission rate when the plant is operating at a minimum load condition. Plants often park at this load for a few hours overnight to avoid the added expense and higher emissions of a startup and shut down cycle. As noted, any period at minimum load, and any load below roughly 75% of plant load, will exceed the proposed standard.

In addition, duct burner operation is not able to satisfy the proposed standard. Duct burners are installed in the HRSG to increase the steam turbine output. This operating scenario is less efficient and has a higher CO_2 emission rate than baseload operation; however, this scenario provides quick, clean, affordable additional peaking generation when needed. This operating mode is much cleaner than starting a simple cycle turbine to satisfy grid demand. As the electricity must come from somewhere, this is the best, cleanest solution.

As Figure 10 clearly indicates, the only operating conditions for a state of the art “H” class gas turbine design that satisfy the proposed standard are at or near baseload. Additional factors that must be considered include start and stop cycles, periods of back-up fuel operation on oil (with an inherent emission increase of 40% due to different fuel carbon content), degradation, and compliance tolerance. As a plant transitions through these various operating conditions, it simply cannot achieve the proposed emission standard.

GTA Combined Cycle Plant Analysis

The GTA has conducted an analysis of two (2) recently built “H” Class gas turbine plants. Additional plants can and will be analyzed with more time beyond the 75 day commenting period.

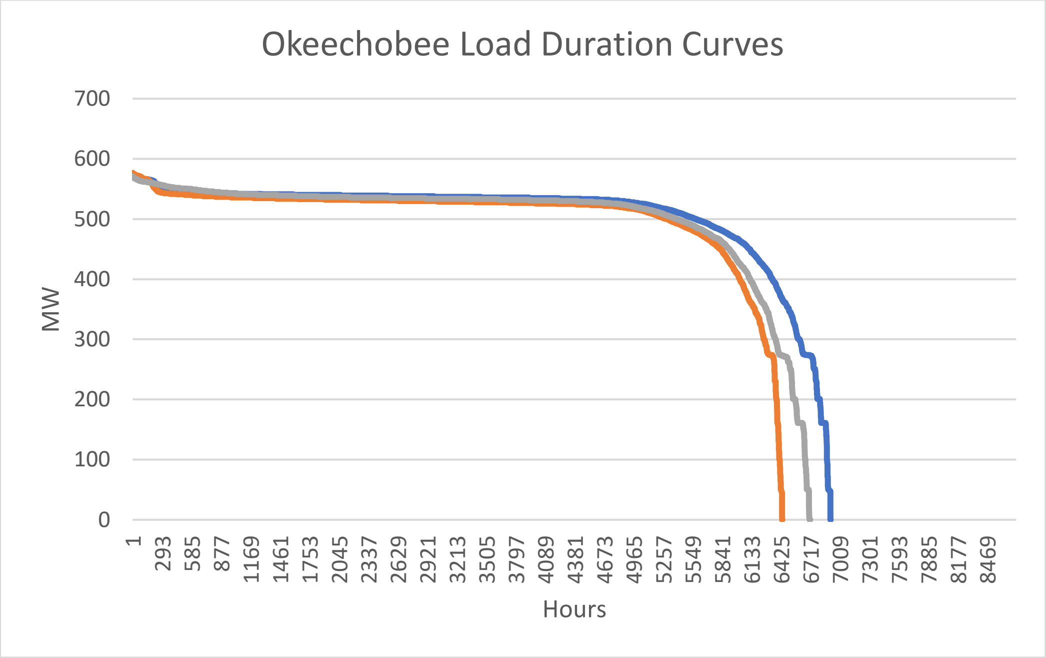


Figure 11: Okeechobee Operating Load Duration Curve - 2022

Figure 11 depicts the duration of time the three (3) units at the Okeechobee Clean Energy Center operated at various load levels throughout the year. As EPA notes, the Okeechobee Clean Energy Center, located in Florida, includes three (3) “H” Class gas turbines supplying steam to one (1) steam turbine with a cooling tower. The key takeaway from the graph is this plant spends a vast majority of its operating time at or near baseload conditions and included only 24 starts/unit during the year (an average of less than one start every other week). This plant’s operating profile resulted in an industry leading emission rate of 700 lb CO_2/MWh during the 2022 operating year. The plant average of 700 lb CO_2/MWhr during 2022 was even better than the 730 lb CO_2/MWhr identified by EPA for the year 2021. This plant would be expected to experience an approximate additional efficiency degradation of 0.5% over this time. This highlights that the differences in performance outweigh the effects of baseload efficiency.

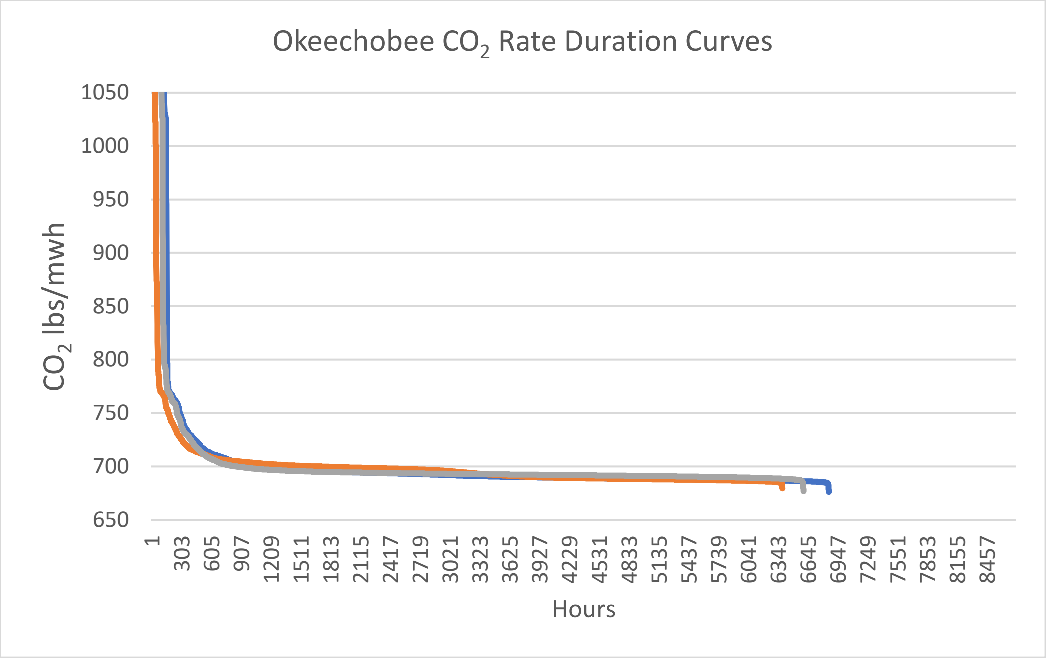


Figure 12: Okeechobee CO_2 Intensity Duration Curve - 2022

Figure 12 presents the same Okeechobee units operating profile with number of hours at various CO_2 intensity rates. This graph clearly shows the three (3) units spending significant baseload operating hours near 700 lb CO_2/MWhr. The periods of high CO_2 intensity are start-up and shutdown.

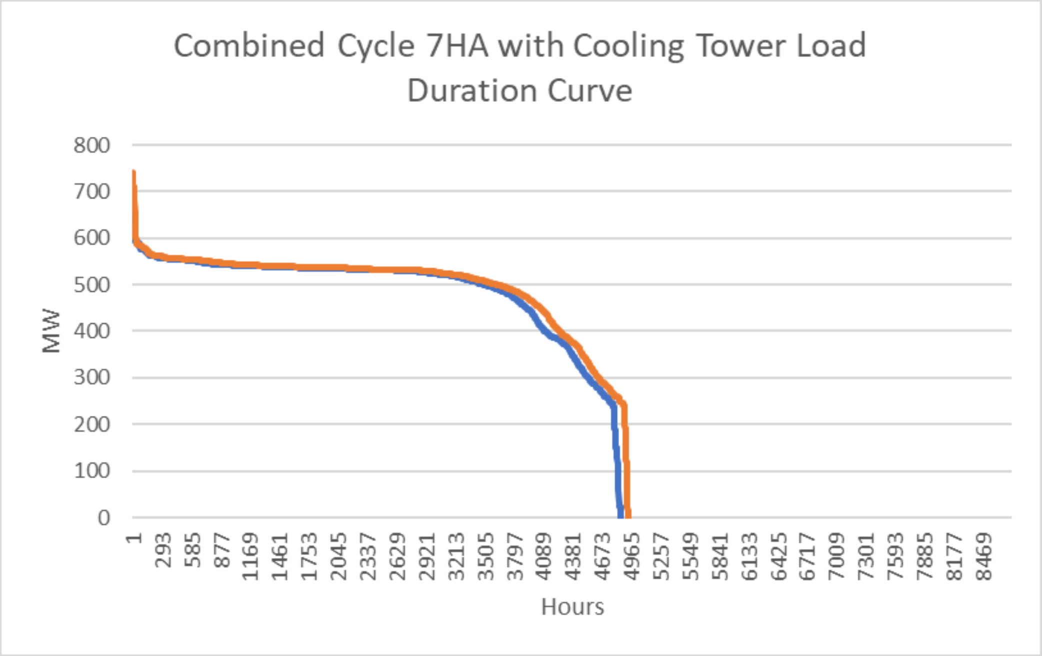


Figure 13: Combined Cycle "H" Class GT Operating Load Duration Curve - 2022

Figure 13 depicts the annual operating duration for two (2) "sister units", located in Michigan. This facility includes two (2) "H" Class gas turbines supplying steam to one (1) steam turbine with a cooling tower. The plant includes the same "H" Class technology and is substantially similar in design to Okeechobee, but spent less time in total operation, spent more time at part load, and spent a few hours of duct firing with 18 starts/unit during the year (Note: the two units at this facility are rated at less than 600 MW each and the few hours shown above 600 MW are a reporting or measurement anomaly). This plant's operating profile resulted in 764 lb CO_2/MWh during the 2022 operating year, essentially at the proposed emission standard.

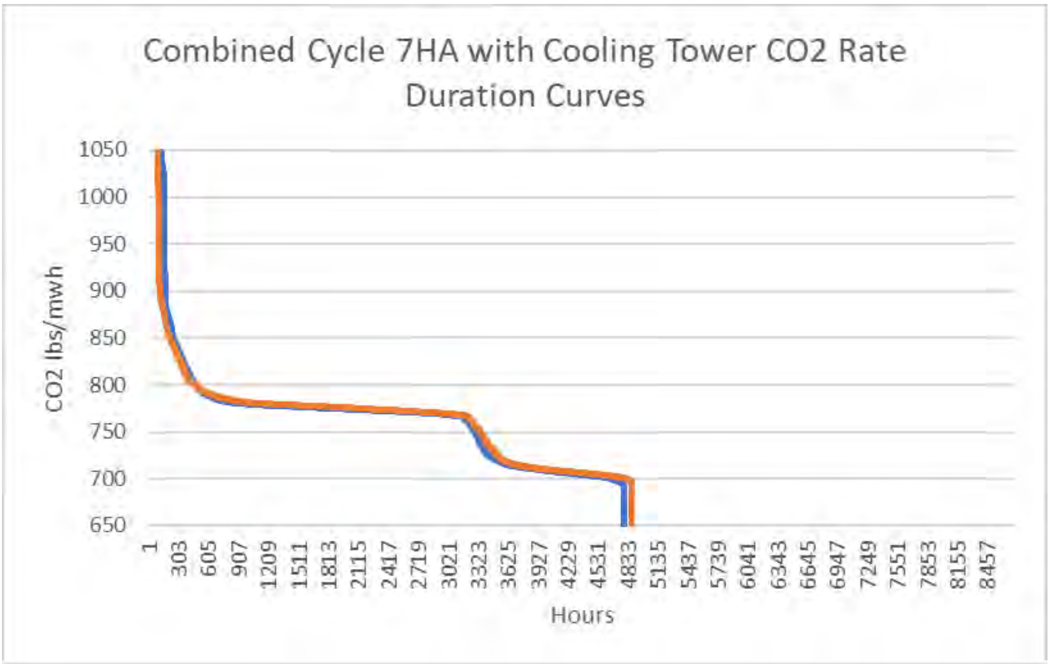


Figure 14: Combined Cycle “H ”Class GT CO_2 Intensity Duration Curve - 2022

Figure 14 presents the same facility operating profile with number of hours at various CO_2 intensity rates. As would be expected, these units spend less time at baseload and as a result, have fewer hours with CO_2 intensity levels below 770 lb CO_2/MWhr. This graph clearly shows that the two (2) units spend significant operating hours at part load and some hours duct firing, which results in a CO_2 intensity of around 764 lb CO_2/MWhr (with the higher values due to the start-up and shutdown cycles). The most important takeaway in comparing Okeechobee and this “sister facility” is that while most ‘frame’ sized units can achieve less than 770 lb CO_2/MWh during “ideal” baseload operation, the Okeechobee units spend much more time at or near baseload, resulting in very different annual CO_2 intensity rates: baseload efficiencies are similar for the two sites, yet one results in a 12-operating month average ~ 64 pounds higher than the other (Note: as with the over reported MW for a few hours, there are a few hours of underreported CO_2 intensity).

The inclusion of these operating profiles in the GTA comments are provided to clearly demonstrate the impact that site-specific design requirements and variable load profiles will have on the resulting CO_2 intensity for an individual unit. These profiles and resulting emission rates clearly justify the need for a higher emission standard and the adverse impacts that would result if the currently proposed standard is promulgated.

Note that the above discussion pertains to larger (> 2,000 MMBtu/hr) combined cycle units and that the rule covers units down to 250 MMBtu/hr. The lower end of the sliding scale limit as proposed for these smaller units (from 250 up to 2,000 MMBtu/hr) needs to account for the lower thermal efficiencies inherent in this size class. The limit proposed as 900 lb CO_2/MWhr is not appropriate down to the 250 MMBtu/hr level. The limit at this end of the scale should be no less than 1,100 lb CO_2/MWhr to account for actual efficiencies.

The EPA states in section VII.G.1 of the rule preamble, that "With respect to small, combined cycle combustion turbines, the best performing unit is the Holland Energy Park facility in Holland, Michigan, which commenced operation in 2017 and uses a 2-on-1 configuration and a cooling tower. The 50 MW turbine engines have individual heat input ratings of 590 MMBtu/h and serve a single 45 MW steam turbine. The facility has maintained a 12-operating month, 99 percent confidence emissions rate of 870 lb CO2/MWh-gross. This long-term data accounts for degradation and variable operating conditions and demonstrates that a base load combustion turbine EGU with a turbine rated at 250 MMBtu/h should be able to maintain an emissions rate of 900 lb CO2/MWh-gross."

It is a stretch to assume that a 250 MMBtu/hr unit can meet the same emissions rates of units more than twice this size (i.e., 590 MMBtu/hr). The Holland Energy Center cites values around 60% thermal efficiency, however units down in the 250 MMBtu/hr range will only achieve thermal efficiencies in the low 40% range. Accordingly, the higher limit for units at the 250 MMBtuhr level should be increased to 1,100 lb CO_2/MWhr, which is more reflective of actual combined cycle performance for units in this size range.

Existing (Baseload) Turbines

While the proposed rules for existing turbines only apply to the baseload subcategory and in addition, commence with Phase-2, should EPA decided to apply the Phase-1 BSER standards for new, modified, or reconstructed gas turbines to existing gas turbines, all GTA comments provided above are applicable. GTA comments related to the co-firing of hydrogen fuel and the use of carbon capture and sequestration (CCS) are included in following sections and apply to both new/modified/reconstructed and existing gas turbines. Regarding existing gas turbines, the GTA would like to offer the following comments.

- While GTA understands EPA's recent (June 12, 2023) clarification that the steam turbine (ST) power output (MW) shall be included (on a pro-rated) basis when determining rule applicability to existing units based on total MW, this actually has the effect of forcing the most-efficient combined cycle gas turbine plants to curb their operation, thereby leading to less-efficient units (with higher CO_2 intensity) to make up the difference in electricity grid requirements. The GTA does not agree with including ST MW in the unit applicability determination (ST capacity does not change the heat input or emissions generated by the plant), which should be based on gas turbine nameplate rating alone. Due to electricity grid, market and industry drivers, combined cycle units with ST will be 'naturally selected' first to fill electricity needs and will do so with the lowest-achievable CO_2 intensity, but only if the ST MW are not included in determining rule applicability.

- EPA should consider adding remaining useful life considerations to the existing gas turbine category as they do for the coal-fired units in the proposed rule.

- EPA should clarify if the capacity factor threshold for existing gas turbines is based on multiple years, current years, anticipation of future year operations, or some average.

- In addition to the challenges with CCS (as discussed below), it is difficult in many, and potentially impossible in some situations to retrofit an existing facility with CCS, due to limited real-estate/footprint, accessibility, distance to potential geological carbon storage locations, etc.

- EPA should perform a revised regulatory impact assessment that treats H_2 co-firing and CCS as endogenous (dependent) rather than exogenous (independent) variables to balance potential costs versus regulatory scope.

- EPA should give serious consideration to implementing a cap-and-trade program (like the one for the Acid Rain Program) on CO_2 mass emissions for existing gas turbine plants in lieu of promulgating specific BSER solutions. The use of H_2 co-firing and CCS are still available to owners/operators, but the added flexibility will result in greater overall reduction in CO_2 emissions than will occur under the currently proposed rule. From the EPA's website, "Reducing emissions using a market-based system provides regulated sources with the flexibility to select the most cost-effective approach to reduce emissions and has proven to be a highly effective way to achieve emission reductions, meet environmental goals, and improve human health."[4]

Technology Applicability

The proposed rule is applicable to gas (combustion) turbines in both simple and combined cycle operation. However, Reciprocating Internal Combustion Engines (RICE) are not considered in this standard. There are numerous facilities in the U.S. consisting of multiple reciprocating engines with a generation capacity more than 100 MW. A single RICE OEM[5], reports their fleet of reciprocating engines includes 76 GW of installed capacity globally. Of this global capacity, at least 1.8 GW of generation are located in the U.S. (including the Dominican Republic) at 13 plants with an average capacity of 140 MW each. This proposed regulation imposes significant burdens on the gas turbine industry regarding capacity restrictions, efficiency standards and conversion to H_2 co-firing and CCS, with no corresponding regulatory requirements for RICE technology. Hence, promulgation of this proposed regulation would result in an imbalanced regulatory burden on these two competing technologies, leading to the potential unintended consequence of shifting the market towards large RICE installations to circumvent the regulatory burdens. The GTA implores EPA to resolve this regulatory imbalance between generation technologies.

---

[4] https://www.epa.gov/acidrain/acid-rain-program

[5] https://www.wartsila.com/energy/learn-more/references?region=north-america-caribbean&application=Flexible-baseload

Hydrogen Blending Requirements

The members of the GTA represent a majority of the Gas Turbine Manufacturers (OEMs) doing business in the United States. GTA members all have experience combusting fuels with H_2 blends and can combust fuels with various levels of H_2 blending. All OEMs are working to expand their H_2 blending capability. The ability to combust the proposed high levels of H_2 in the OEM's respective Low NO_X Combustor technologies is being developed. Each OEM has development timelines for high H_2 and Low NO_X combustion technology which is generally consistent with the timelines in the proposed rule. In short, the OEMs are confident that if the H_2 is available, we can combust it.

The GTA comments in this letter are focused on gas turbine technology. Again, the OEMs have experience firing H_2-blended fuels. Much of this experience is associated with industrial facilities with high H_2 fuel available, or demonstration projects with H_2 fuel brought in for testing. Significant infrastructure will be necessary to first, economically produce the high levels of H_2 necessary to meet the standards (especially low-GHG H_2), and second, transport the H_2 fuel to every plant subject to the proposed H_2 requirements. In addition, current permitting requirements for the necessary infrastructure (piping, rights-of-way, etc.) will add considerable time and uncertainty to when (and if) the needed H_2 will be available. Hence, there must be relief in the rule for plant owners and operators that simply are unable to achieve access to the amount of H_2 necessary to supply gas turbines.

The GTA also recommends that EPA coordinate its definition of "low-GHG H_2" with that of the Inflation Reduction Act (IRA). EPA defines low-GHG H_2 as H_2 produced with less than 0.45 kg CO_2 per kg H_2 from 'well to gate'. However, the IRA (Section 45 of the U.S. Tax Code) provides several definitions of 'qualified clean hydrogen' that differ with this, ranging from 0.45 to 4 kg CO_2/kg H_2. It is hard to imagine different H_2 production, delivery and pipeline systems being constructed to transport H_2 with different CO_2 product intensities.

Carbon Capture and Sequestration

As stated, the GTA members fully support the transition to a clean, low-GHG electricity generation technology. Carbon Capture and Sequestration (CCS) is a potential technology to support this transition. The GTA members are in the process of developing, designing, and integrating Carbon Capture systems with the potential to capture carbon consistent with the levels specified in the proposed rule.

The GTA does however dispute that this technology is proven as available, and the EPA is engaging in "crystal ball" projections of technology capability within the proposed timeline. Carbon Capture technology has been demonstrated at limited sites at relatively low capacity. The Carbon Capture technology works. However, this technology has not been demonstrated at scale on a gas turbine plant, which provides load following and firming capacity with variable operation. In addition, this carbon capture technology requires significant design, review, permitting, development, and construction time to become fully implemented. Necessary infrastructure, in particular CO_2-dedicated pipelines, permitting requirements for the necessary infrastructure (piping, rights-of-way, etc.), and geological evaluation and development of sequestration sites will also be required. Industry capability to provide these systems within the proposed timeline will be extremely challenging. While EPA accurately notes there are a number of FEED studies currently in progress, these are, by definition, in the research (study) phase and do not constitute ‘proof’ of a demonstrated technology.

Another consideration is that the CCS system will not likely be able to start as quickly as the gas turbine plant and may be challenged to maintain full removal during rapid load fluctuations. These limitations make carbon capture technology challenging for load following baseload plants with variable operation, and completely inappropriate for either intermediate or peaking gas turbines. In addition, the large parasitic load a CCS system will have on a plant (upwards of 30% or more) will result in less electricity to the grid (and hence, a higher CO_2 intensity). This reduction in useful electricity will need to be made up by either increasing the output of the plant (only possible if it is designed to account for this in the first place) or by dependence on other, potentially less efficient sources. EPA should consider a higher CO_2 intensity limit on a net basis for existing gas turbine plants that utilize CCS, to account for the parasitic load. As with the H_2 co-firing BSER, relief must be provided to plant owners and operators that go the CCS BSER route and for situations in which the full CCS infrastructure is simply not available to support the plant requirements.

Lastly, EPA had requested input regarding the CCS system 12-operating month removal efficiency. CCS design projections target a 90% removal while the CCS is fully operational. As with any new technology development and deployment, a significant shakedown period will be required to ensure full system reliability. The gas turbine must be able to operate during periods the Carbon Capture system is not available to ensure electrical grid reliability. Carbon Capture systems, especially initial installations, will not be able to operate at full capacity as the technology is developed. Using the 12-operating month rolling average for CCS removal efficiency, a Phase-2 standard of no higher than 50% should be required, and a Phase-3 standard of no higher than 75% should be required.

GTA Responses to Specific EPA Requests for Input

The following are GTA responses to various EPA requests for comment and input throughout the proposed rule. We are unable to address all EPA requests but have attempted to provide responses to those that are more in the OEM purview. EPA requests are first stated in *italics*, followed by the GTA’s response.

EPA is proposing regulatory text to clarify that the output from integrated renewables is included as output when determining the NSPS emissions rate. The EPA is also proposing that the output from the integrated renewable generation is not included when determining the net electric sales for applicability purposes.

- **GTA Response:** we agree with EPA that integrated renewable output should be counted as the ‘denominator’ (MW) when determining compliance with the limits. Whether or not the output should be included when determining net electric sales for applicability purposes should be left to the individual EGU's on a case-by-case basis, to encourage flexibility in reducing overall CO_2 emissions.

EPA is soliciting comment on the potential for an earlier compliance date for the second phase, for instance, 2030 for units co-firing 30 percent hydrogen by volume (for both Intermediate and Base Load EGU) and 2032 for units installing CCS (for Base Load EGU).

- **GTA Response:** we believe the proposed dates will be challenging to satisfy and recommend against moving these compliance dates forward.

EPA is soliciting comment on whether Low Load combustion turbines should apply the second component of BSER (co-firing 30% H_2 by vol. by 2032).

- **GTA Response:** No, significant infrastructure and H_2 production capacity would be necessary to support an H_2 co-firing standard for combustion turbines in this subcategory.

EPA is soliciting comment on whether Intermediate Load combustion turbines should be subject to a more stringent third-phase standard based on higher levels of low-GHG hydrogen co-firing by 2038.

- **GTA Response:** No, significant infrastructure and H_2 production capacity would be necessary to support a higher H_2 co-firing standard for combustion turbines in this subcategory.

EPA is soliciting comment on whether Intermediate Load combustion turbines should be subject to a Phase I standard of 1,100 (instead of 1,150) lb CO_2/MWh.

- **GTA Response:** No, as previously noted in these comments, the 1,150 lb CO_2/MWh standard is already too restrictive and will pose a significant challenge for future gas turbines to meet, and the GTA is advocating for this value to be increased (to 1,300 lb CO_2/MWh).

EPA is soliciting comment on whether the electric sales threshold used to define Intermediate and Base load units should be reduced further.

- **GTA Response:** No, as previously noted in these comments, the GTA advocates for a higher threshold to allow operational flexibility for combustion turbine generating units.

EPA is soliciting comment on the percentages of hydrogen co-firing and CO_2 capture, the dates that meet the statutory BSER criteria for each pathway, whether the Agency should finalize both pathways as separate subcategories with separate standards of performance, or whether it should finalize one pathway with the option of meeting the standard of performance using either system of emission reduction – e.g., a single standard of 90 lb CO_2/MWh-gross based on the application of CCS with 90 percent capture, which could also be met by co-firing 96 percent low-GHG hydrogen.

- **GTA Response:** Achievement of the standards (limits) should be technology neutral. It would simplify the rule if the CCS emission standard were applicable at a single compliance date of 2038 regardless of technology path. Note that 90% CCS is highly challenging as gas turbine exhaust contains much less CO_2 (~3%) compared to traditional coal plants. The exhaust gas from gas turbines must (currently) be specially processed to concentrate the CO_2 through methods such as exhaust gas recirculation or other novel means prior to removal in amine-based solution.

The EPA solicits comment on whether, and the extent to which, high efficiency designs also operate more efficiently at part loads and can start more quickly and reach the desired load more rapidly than combustion turbines with less efficient design efficiencies.

- **GTA Response:** the short answer to this question is typically not; gas turbines in both simple and combined cycle operation are their most efficient at base load, with decreasing efficiency at lower load levels (hence, increasing CO_2 lb/MWh emissions at part-loads). Combustion turbines with higher baseload efficiency will tend to have comparable higher part load efficiency, however there are many factors which influence individual turbine designs so while it is a trend, there is not a universal correlation.

The EPA is soliciting comment on whether the BSER for new low load combustion turbines should be the use of high efficiency simple cycle technology. However, since the method of operation has a substantial impact on the emissions rate, it may not be feasible to prescribe or enforce a single numerical standard of performance for affected sources strictly based on design efficiency. Accordingly, the EPA solicits comment on whether it would be appropriate to promulgate such a requirement as a design standard.

- **GTA Response:** GTA supports the clean fuel standard as proposed and agrees with EPA's conclusion that an emission rate for the low load category is not appropriate.

The EPA is soliciting comment on whether continuous carbon dioxide and flow measurements should become the sole means of compliance for this rule (instead of also being able to use calculations using hourly heat input and 'F' factors).

- **GTA Response:** No, as (1) the capital investment and annual operating costs for actual (physical) flow meters would not result in a more accurate determination of the actual CO_2 emitted and (2) the requirement to use measured exhaust flow with a CO_2 monitor (analyzer) adds an undue burden to initial and periodic certification and calibration of the flow monitor device(s). The GTA recommends that the plant operator be given flexibility in choosing the method(s) of compliance demonstration.

The EPA is soliciting comment on the definition of natural gas.

- **GTA Response:** while the current 'definition' of natural gas is fine as-is, a related but slightly different question relates to the use of low-GHG H_2 mixed in with natural gas, and how this should be defined. EPA needs to take this into consideration as well, if not for this rule, then certainly as an overall consideration for 'all' rules.

EPA is taking comment on whether the capacity factor threshold or capacity threshold (50% / 300 MW) should be lower (for instance 40 percent for the capacity factor and 200 MW or 100 MW for the capacity).

- **GTA Response:** the proposed capacity factor and threshold (50% and 300 MW) are appropriate. A lower threshold would impose a significant burden on existing generating units.

EPA is taking comment on whether HRI (heat rate improvements) should be considered BSER (or a component of BSER) for combined cycle units with a capacity factor of greater than 50 percent and a capacity of less than 300 MW as part of this initial rulemaking.

- **GTA Response:** HRI should be encouraged and considered as part of BSER, however, potential HRI for a specific unit would need to be evaluated on a case-by-case basis. There is no "one size fits all" HRI available to all units and many HRIs that are available have already been deployed.

EPA is taking comment on if there are efficiency impacts from co-firing hydrogen.

- **GTA Response:** efficiency impacts may be experienced in cases where firing temperature is reduced to maintain engine NO_X at a reasonable level (either to meet NO_X limits out of the GT exhaust directly, or to control the amount of NO_X entering an SCR system), as lower firing temperature typically results in reduced efficiency.

EPA is taking comment on the appropriateness of low-GHG hydrogen as a BSER for combustion turbines larger than 300 MW with capacity factors of greater than 50 percent.

- **GTA Response:** although co-firing with low-GHG hydrogen is one potential (viable) pathway to reduce GHG emissions from gas turbines, it is uncertain as to whether the infrastructure for the production and supply of low-GHG H_2 will be sufficient by the time it is 'needed' and hence, the limits should be technology-neutral.

EPA is taking comment on a 2035 CCS based BSER standard and whether that standard could reasonably be applied earlier. Similarly, the EPA is taking comment on the timing of a low-GHG hydrogen based BSER and whether a 30 percent low-GHG hydrogen standard could be implemented earlier than 2032, or if low-GHG hydrogen supply infrastructure development suggests it should be later.

- **GTA Response:** No, GTA believes that the proposed dates will be challenging to satisfy and recommend against moving these compliance dates forward.

EPA is taking comments on what units should be part of whatever action the EPA finalizes as a result of the proposal, and whether Intermediate and Peaker (Low Load) Subcategory gas turbines should be included and given the same limits (with the same or similar pathways) as the new units.

- **GTA Response:** the GTA agrees with the EPA statement in the proposed rules that "the EPA believes that limits to infrastructure and capability to build carbon capture systems or co-fire large amounts of hydrogen caution against a first rulemaking addressing emissions from existing turbines covering all combustion turbines". The GTA recommends leaving 'smaller' gas turbines (e.g., those < 50% capacity factor and/or < 300 MW in size) out of any initial rule making for existing gas turbines and revisit at a later date once the impacts (amount of GHG reduction achieved based on the currently proposed rule) become clearer.

GTA Requests for EPA Clarifications

There are several items for which the GTA is requesting the EPA provide some clarification, either in the final rule proposal or through some sort of guidance document, summarized as follows.

- How does one determine the "12-operating month and a 3-year rolling average basis"? Does the 1st month roll 'off' the average at the end of the 13th month? Does the 1st year roll 'off' the average at the end of the 4th year … or is it by month (1st month rolls 'off' the average at the end of the 37th month)?

- If an EGU chooses to comply with the Intermediate Load Subcategory limit and part-way through the year (or 3-year rolling average period) determines it may exceed the limit, can it 'switch' to operating as a Low Load Subcategory EGU (assuming it has not yet exceeded the annual 20% capacity factor)?

- For the Low Load Subcategory, is the standard of 120-160 lb CO_2/MMBtu (HHV) an actual 'limit', or is it to be utilized as an 'emissions factor' to determine total mass of CO_2 emitted? It is often that one can 'back-calculate' a value of CO_2 in units of lb/MMBtu that exceeds 120, using the measured or calculated CO_2 mass flow rate and the fuel flow (heat input). In addition, if the facility air permit limits the fuel combusted to those listed, then can EPA confirm that there would be no requirements at all to follow? If the standard is a 'limit' the rule needs to specify these values are based on two significant digits.

- Regarding the Base Load Subcategory, Phase II limits: must an EGU start using the Low-GHG Hydrogen Pathway in 2032, then have an option to switch to the CCS Pathway in 2035 … or … can an EGU continue to follow Phase I limits until 2035 and then start down the CCS Pathway? Are these two pathways an either/or choice, or must both be used? If following the hydrogen pathway commencing in 2032 (with 30% H_2 by vol. co-firing), must that same pathway be continued (with 96% H_2 by vol. co-firing) commencing in 2038? These questions also apply to Existing units (> 300 MW).

Gas Turbine Association

Appendix A

Background Information Related to CO_2 Production and the Critical Role of Gas Turbines in Meeting Electricity Generation Grid and Market Requirements

Essential background information is provided in the following sections to ground the GTA's commenting to ensure a basic understanding for all stakeholders around the core generation of CO_2, Electricity Market Dynamics, and the role of gas turbines in electric generation to provide electrical grid reliability while continuing to transition to clean electric generation technology.

Physics of CO_2 Formation

When combusting natural gas or any other carbon-based fuel, every carbon atom which comes in with the fuel is converted to CO_2. This is basic combustion physics and, unlike a pollutant such as NO_X, which can be mitigated through combustion, there is no way to control CO_2 emissions within the combustion process. The only means to reduce carbon emissions within the combustion turbine is to improve efficiency - burning less fuel for each MWhr of energy produced. Higher efficiency leads to lower CO_2 lb/MWhr.

Market Incentives for Efficiency

Today's power plants are designed, maintained an operated at levels of high efficiency. The gas turbine market is highly competitive. In this marketplace, efficiency is the driving factor. For each bidding opportunity, the OEM offering is evaluated for cost and performance. While evaluation values vary, 0.1% (one-tenth of a percent) of improved efficiency is worth approximately $1.4 Million, and a few tenths of a percent of efficiency can make the difference between winning or losing an order worth billions of dollars. With these incentives, power plant designers rigorously evaluate available performance options.

Within the EPA documents, the EPA has very accurately identified numerous efficiency improvement options. All commercially viable efficiency improvement options are rigorously evaluated for every plant design to determine the best unit configuration to match the specific site requirements of output, operating duty, annual ambient conditions, cooling technology (based on water availability), etc. Again, these options are evaluated for each site to determine if they provide overall annual site efficiency improvements.

Market Incentives – Economics – Already Exceed the Anticipated Benefits of the Clean Power Plan

Economics significantly influence both plant design and dispatch of electric generating resources towards efficient and low CO_2 grid wide generation. EPA, in their support of the vacatur of the Clean Power Plan noted "because of ongoing changes in electricity generation – in particular, retirements of coal-fired electricity generation – the emissions reductions that the CPP was projected to achieve have already been achieved by 2021." These coal retirements, and the shift towards a combination of renewables and low emitting natural gas generation, was driven by the aging coal fleet and other coal environmental regulations, but mostly due to the economics of low-cost natural gas coupled with highly efficient combined cycle technology leading to an economic shift to clean gas generation. Economic incentives towards high efficiency and low CO_2 emitting generation inherently exist in the market. Additional market incentives will likely further drive CO_2 reductions while allowing the necessary generation flexibility to ensure electric grid reliability.

Electric Generation Load and Dispatch

A typical daily electric demand profile includes periods of minimum demand during the nighttime while most people are asleep, with a ramp in the morning as people wake and turn on the numerous electric appliances on which we all depend, to a peak demand in the late afternoon and early evening, especially on hot summer days with high air conditioning load, then back to a decreasing demand overnight. The magnitude of the peak demand will vary seasonably. Typically, the highest peak occurs on hot summer days with high air conditioning load. Some regions of the country experience peak demand in winter months if electric heating is common.

Overlay this daily demand load with increased electric generation from solar energy, which has a peak supply during sunny daytime periods. This supply can change significantly with cloud cover and seasonal variation. Add in wind turbines which supply variable generation dependent on localized wind patterns. To balance generation with changing demand, the grid operators accept the renewable generation first. The remaining baseload generation requirements are supplied by a combination of Hydro-Electric, Nuclear, Natural Gas Combined Cycle, and Coal. When there are short term capacity needs, the combined cycle plants will increase load if there is remaining capacity, utilize duct burners to increase output, or deploy peaking turbines for a few hours to cover that demand.

The grid operators will dispatch the units with the lowest variable cost of electricity first (variable costs primarily include fuel, operation and maintenance costs). Lowest variable cost is generally in the order of renewables, nuclear, natural gas and then coal. This distribution will vary with the generating assets available within the grid operators' region. Within the profile of available gas turbine units, the units with the lowest variable cost, which are the most efficient units and have the lowest CO_2 emissions, will be dispatched first. In this way, market forces drive the dispatch of the lowest GHG emitting technologies.

The Role of Gas Turbine Simple Cycle and Combined Cycle Plants

Power plant operators would like nothing better than to start their combined cycle plant, bring it to near baseload and let it continue to run. However, that is far from the reality of how most plants operate. This stable baseload operation is the most efficient and results in the lowest annual CO_2 emission intensity (lb CO_2/MWh). However, the actual operating profile of combined cycle plants is far from this ideal stable load operation.

Gas turbine equipment can be dispatched when needed, start quickly, and load rapidly. These capabilities make gas turbine units favorable to provide load "firming" capacity. Combined cycle units provide a majority of the baseload and long-term firming capacity. Simple cycle gas turbines provide shorter period generation when that is required. As load rises in the morning, many simple cycle turbines start, run until the solar capacity increases, shut down, then begin operating again in the evening as demand again increases and solar declines, running until demand subsides.

Combined cycle unit operation can vary greatly from one facility to another, ranging from baseload steady operation to highly variable operation with frequent starts, including significant periods of part load operation. This variability in operation results in a wide range of annual CO_2 emission intensity. Many plants today operate under Automatic Generation Control (AGC) in which the grid operator, who is responsible to ensure reliable grid operation, is driving the plant load. The owner operator has limited control over how the plant is operated.

In summary, the gas turbine industry deploys gas turbines which provide generation in a wide range of operating missions ranging from baseload capacity that operates mostly at or near baseload with few starts and stops, to simple cycle turbines that start two or more times a day and operate just a few hours per start. These units operate to satisfy the demand of the widely and rapidly transitioning electric market.

Future Grid Demands and Role of Gas Turbine Plants – Need for Operational Flexibility

Gas turbine power plants will continue to play an essential role of providing reliable, dispatchable, clean, and affordable electricity. This role will become increasingly critical as the electric industry continues to transition to a cleaner, lower GHG generation profile. How this role is met, regarding future capacity factors, duty cycles, and specific operating scenarios, is difficult to predict, but is anticipated to be at least as varied as the demands placed on today's equipment. The electric industry is undergoing unprecedented changes with the rapid transition towards cleaner technologies. Additional considerations follow.

- Closure of coal and nuclear plants are decreasing baseload capacity, often filled by gas turbines.
- Increased deployment of solar electrical generation increases daytime supply but requires larger load swings during the early morning and evening hours.
- Increased wind generation introduces significant capacity, though this wind capacity is variable and literally dependent on the weather. Wind capacity requires a dispatchable generation supply to provide firming power.
- Electrification of the economy, especially the transportation sector, will introduce significant additional load to the electrical system.
- Energy storage may assist in stabilizing generation against demand, though there are significant cost and infrastructure challenges around widespread deployment of these technologies.
- Future development of CCS technology, hydrogen production and associated infrastructure will support cleaner gas turbine generation. Costs and timing are uncertain.
- Small Modular (Nuclear) Reactors (SMR) could be a major player in the future electric economy.

Predicting the exact role of gas turbines within this highly dynamic landscape is near impossible. Changes in timelines and cost structures around these various technologies significantly influence any future projections of the electric mix of technology. To highlight the inherent uncertainty in today's electricity market, many combined cycle units operating today are operating along vastly different operational missions than anticipated when they were first installed. This crystal ball look into future generation will be even more uncertain.

Choice of Plant-Specific Turbine Model

The gas turbine industry offers a wide range of turbine sizes to satisfy local electrical generation needs. This wide range of sizes and options is necessary to satisfy specific grid requirements. Large turbines satisfying high grid capacity needs, smaller turbines satisfying smaller capacity needs, and the appropriate peaker size turbine will depend on localized grid requirements. A first step in any project development is an interconnect approval in which the grid operator evaluates the allowable plant capacity that can be accommodated at the interconnect location. As part of this study, any necessary grid upgrades and costs are assessed. These interconnect requirements very often dictate the allowable plant size. The combined cycle plant design and turbine choice are determined to best match the maximum allowable plant capacity.

Sizing the plant to the necessary capacity is the first step in determining the most efficient solution for that site. As EPA accurately notes, larger gas turbines with higher operating pressures and temperatures are more efficient; however larger is not always better. It is far more efficient to design the plant to the capacity requirements than to overdesign the plant and then continuously run that plant at a part loaded condition.

Gas Turbine Association

Appendix B

Gas Turbine Association Current Membership

Camfil Power Systems
GE Gas Power
Mitsubishi Power
Mitsubishi Power Aero LLC
Power Systems Mfg., LLC (PSM)
Pratt & Whitney
Reuter-Stokes
Siemens Energy
Solar Turbines
Strategic Power Systems, Inc.
The Pennsylvania State University
Turbine Logic
University of Central Florida (UCF)
University of Connecticut (UCONN)