

Solar Turbines

A Caterpillar Company

Solar Turbines Incorporated

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December 17, 2004

Chairman Pat Wood, III
Federal Energy Regulatory Commission
888 First Street, N.E., Suite 11A
Washington, D.C. 20426

Re: Comment on Natural Gas Interchangeability; Comments of Solar Turbines Incorporated

Dear Chairman Wood:

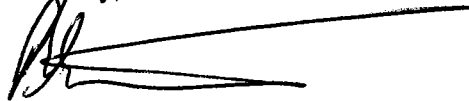
Solar wishes to submit our perspective on the current dialogue on Natural Gas interchangeability and, in particular, the consensus reached by the Natural Gas Council's Technical Task Force on interchangeability.

Solar Turbines is a leading manufacturer of gas turbine and turbo machinery frequently utilized in natural gas compression and distributed power generation, particularly in combined heat and power applications. Solar Turbines' generator-set products range from as little as 1.5 megawatts to as much as 50 megawatts in multiple units – relatively small turbines within the range the Commission hears from relative to the challenges of Natural gas quality and interchangeability.

Solar Turbines has recently become aware of some dissention among some of the turbine manufacturers as to the consensus on interchangeability. We understand that some who develop power generation projects using either "frame" or "aero-derivative" turbines have also commented from the perspective of the turbine user. Attached, please find the comments of one of Solar Turbines' leading subject matter experts on this matter. As well, we have attached our testimony we delivered to the FERC in March of this year.

Solar Turbines is very active in the industry, having developed our first turbine product for power generation as well as the gas compression industry, in the early 1960s. We believe that it is important to share with the Commission, going on record early, with the understanding that we believe our turbines can operate under the industry consensus. We don't want the commission to think that the views represented by the other turbine manufacturers who opted out of the consensus, are the views of the entire industry.

Sincerely,



Richard S. Brent
Director, Government Affairs
Solar Turbines Incorporated

cc: Commissioner Nora Mead Brownell
Commissioner Joseph T. Kelliher
Commissioner Suedeem G. Kelly
Mr. Edward Murrell

Solar[®] Turbines

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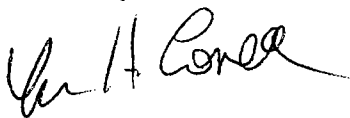
Solar has reviewed the proposed interchangeability standard developed by the industry's technical task force and can confirm that Solar's SoLoNOx gas turbines can utilize this range of fuels without issue.

Wobbe (HHV)	1200 - 1400
Higher Heating Value	950 - 1110
Max Butanes+	1.5%

The proposed standard is already within the range of fuel variation that Solar currently allows in our product Fuel Specification. The comments contained in Solar's March 2004 filing with FERC remain valid and are included in the enclosed. The range of fuels in the proposed interchangeability standard are within the range of fuels for which the document was written.

It is worth noting that in the filing, Solar advised that with the range of fuels Solar has defined as "standard" in the company fuel specification, an increase in NOx emissions of up to 5 ppm is possible (reference pg 5). Solar has completed additional analysis of fuels in the proposed interchangeability range of fuels and estimates that NOx emissions will increase by less than 3 ppm.

Sincerely,



Luke Cowell
Solar Turbines Incorporated

Enclosure

**BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION
UNITED STATES OF AMERICA**

Natural Gas Interchangeability

Docket No. PL04-3-000

COMMENTS OF SOLAR TURBINES INCORPORATED

Pursuant to the Notice Requesting Written Comments issued by the Commission in this docket on February 20, 2004, Solar Turbines Incorporated (“Solar Turbines” or “Solar”) is pleased to submit the following comments. These written comments are based on the oral presentation made at the public conference by Solar Turbines engineer Luke Cowell.

Introduction. Solar Turbines is a manufacturer of gas turbines for industrial applications with engines ranging in size from 1.2 to 15 MW. Solar Turbines is a wholly owned subsidiary of Caterpillar, a Fortune-500 manufacturer of earth moving equipment and engines for the trucks and power generation. Solar’s principal markets are in the oil production and gas transmission industries as well as in power generation. In these market sectors Solar’s gas turbine engines are used for gas transmission, mechanical drive for gas and oil production, power generation, and combined heat and power applications. Solar has significant experience in these markets with over 11,000 turbines in service world wide, and more than 1 billion cumulative operating hours. Of these nearly 7,000 are used in the oil and gas industries and over 4000 for power generation in simple cycle or cogeneration applications. In 1992 Solar offered its first low NOx or

DLE turbine and now has 1160 of these units in service. DLE gas turbines are used predominantly in post '92 applications/installations in the United States.

Critical Fuel Characteristics. Solar's line of gas turbines has been designed to accommodate a broad range of gas fuel compositions that are available or required for these different markets. In fact, Solar has turbines in service using fuels as light as landfill gas and as heavy as natural gas liquids. In these cases, fuel systems and engine hardware modifications are required for successful operation. Solar believes that there are several steps that are required between the gas turbine manufacturer and the end-user so that a broad range of gas fuels can be accommodated in industrial applications. However, first we shall briefly discuss some key fuel and gas turbine characteristics and parameters from a designer, manufacturer, and supplier's perspective.

The first parameter is the **heating value**. This is a measure of the energy content of a fuel. Gas turbine manufacturers generally use "lower heating value." The term "Wobbe Index", which is used to compare the fuel energy content relative to the required size of the fuel system to accommodate the fuel flow. In general, gas turbines require the same heat input from the fuel regardless of the fuel type, so that lighter fuels will have to be used at a higher flow rate.

Solar's gas turbines can operate with Wobbe Index based on lower heating value (LHV) ranging from 300 to 1650 BTU per standard cubic foot ("scf"). However, this broad range cannot be accommodated with a single fuel system. The Wobbe Index

(LHV) range that *can* be accommodated in an application without any changes to the fuel system or engine controls is called a “standard” fuel. Solar defines a standard fuel to have a Wobbe Index (LHV) in the range of approximately 1000 to 1350 BTU/scf. For an application using this range of fuels the Solar standard gas turbine fuel system can be used and no adjustment to engine controls are required. In fact, Solar’s gas turbine packages can be operated with fuel gas varying from 1000 to 1350 Wobbe Index (LHV) without any interruption in operation or power.

For fuels with higher or lower heating values outside of this range, control adjustments must be made and the fuel system size requires changing. However, once the adjustments have been made the gas turbine can operate with a variation of +/- 10% on Wobbe Index (LHV) from whatever design value was targeted.

The following table presents the upper and lower Wobbe index for Solar’s standard fuel and also the high and low Wobbe indices for the LNG fuels discussed at the February 18th public conference in this proceeding. This table allows comparison of fuel types based on the different property definitions used by the various industries. The table offers the Wobbe Index calculated on Lower Heating Value (LHV) and Higher Heating Value (HHV). The two LNG fuel compositions are included to clearly indicate that these fuels are well within Solar’s upper and lower standard fuel definitions.

	LHV (BTU/scf)	HHV (BTU/scf)	Wobbe (LHV based)	Wobbe (HHV based)
*Standard Upper Limit	1200	1320	1350	1486
*Standard Lower Limit	900	998	1000	1108
Oman LNG	1052	1168	1301	1444
Lake Charles Minimum	937	1045	1237	1379
* Solar's Standard fuel limits that define range of operation without modification				

A second key fuel characteristic is the **dew point**. This is the fuel temperature at which condensation will occur. Condensates are typically higher-carbon hydrocarbons but can also include water. Understanding the dew point for the planned gas fuel is important so that provision can be made to keep the fuel temperature high enough to prevent condensates and liquids from “dropping out” anywhere in the system up to the point of combustion.

Solar requires that the fuel temperature be maintained a minimum of 50°F above the dew point at the point of entry into the gas turbine so that no condensation occurs. Any quantity of liquid phase hydrocarbons or water in the gas fuel can cause significant

problems in the gas turbine, both in operation and potentially even in durability. As the concentration of higher carbon hydrocarbons increases there is a point at which the fuel temperature requirements exceed the fuel system component limits. For Solar's equipment this level is typically 200°F.

A third parameter to consider relative to the fuel composition is how the **emission profile** is affected. NOx emissions are a direct function of the flame temperature of the combustion reaction. The flame temperature does vary with fuel composition. Within the "standard fuel" discussed above, the variation is typically not great – depending on the specific fuel make-up NOx increases of only several parts per million ("ppm") are observed as the Wobbe Index (LHV) increases from 1000 to 1350 BTU/scf with common gas turbine hardware.

Referring to the table above, Solar expects less than 5 ppm variation in NOx emissions (or CO emissions) over the range of LNG fuel and pipeline compositions described during the public conference. For fuels with Wobbe index (LHV) greater than 1350, Solar currently does not offer a Low-NOx gas turbine, but rather a conventional turbine. Solar is currently qualifying Low-NOx sub-systems for heavier fuels through turbine testing. The design target is to match the current system emissions performance, however the expectation is that control and fuel system modifications will be required. If no changes were made, NOx emissions would increase continually above 1350 Wobbe Index (LHV) by amounts on the order of tens of ppm.

A final characteristic to be considered is the possibility of **fuel contaminants**.

Gas turbines have fuel systems that are sensitive to fuel contaminants that reach the point of the turbine. The contaminants of greatest concern are liquids, particulates and corrosives. Liquid contaminants, like the liquid condensates already discussed, can cause a variety of problems with the operation and even durability of the turbine. Liquid contaminants generally include oils and water. Oils can cause blockages in the fuel system components. Likewise, particulate loadings of even 30 ppm by weight can cause problems in the turbine. Finally, corrosives including high concentrations of H₂S, CO₂ and water can form acids. Combining these with sodium and potassium will cause rapid corrosion in the turbine hot section.

Steps Required to Accommodate Fuel Variability. Several steps are required between the gas turbine manufacturer and the gas turbine end-user to enable use of a broad range of gas fuels in industrial applications, managing fuel variability and quality issues. Solar's long and wide breadth of experience teaches that following these few steps can go a long way in defining trouble free operation.

The first step is to define and delineate project responsibility for maintaining fuel quality. This starts with sharing information freely so that the combustion turbine supplier understands the fuel quality characteristics and that the end user understands the limitations of the equipment. Once the common language is developed then clear definitions and expectations must be established as to which parties assume what responsibilities. Historically, gas turbine providers have defined the fuel quality

requirements and the primary responsibility for providing quality fuel has been with the user. However, many gas turbine providers are generally willing to assume greater responsibility as part of a broader service agreement. Agreements are becoming increasingly common under which the gas turbine provider serves to maintain and operate gas turbine application after the sale.

The next step in managing variability and quality is to define and accurately assess the fuel composition and expected variability for the project in consideration. A detailed technical analysis is required to complete the most accurate assessment and to avoid future problems. With the detailed fuel analysis, the gas turbine manufacturer can select and supply the optimal fuel and control systems. In addition, fuel temperature requirements can be specified and fuel heating provisioned to prevent condensation. Many fuel analyses do not include any higher hydrocarbons than hexane, but they ought to so as to accurately determine the required fuel delivery temperature. Finally, the emission impact of a fuel can be assessed and the customer advised of this impact early in the project when provisions can be made accordingly.

With the fuel composition clearly defined, the final step is to design and provision adequate fuel treatment. As indicated above the gas fuel needs to be clean and dry when it reaches the turbine. Often this will mean designing a stand alone fuel management “skid” that will contain appropriate hardware such as coalescing filters for removal of liquids and filters for particulate removal. Whichever party has responsibility for the fuel

quality, it is important that the potential for upsets in fuel quality be assessed and appropriate provisions be made to the fuel skid so as to accommodate the worst case.

Even when these steps are followed and a gas turbine application has been operating successfully for some time, the fuel composition or quality may change due to conditions outside the users control. In this event, the designed fuel range for the gas turbine package can usually be adjusted through some simple software changes for modest changes in fuel composition, and hardware and software changes for more a more significant shift in fuel composition. These changes are readily accomplished and Solar has been involved in many such situations with successful outcomes. However, once the gas turbine package is modified to accommodate a different range of fuels, it must operate with fuels with a heating value in the range of +/- 10% of that “new” design point. If the fuel composition were to revert back to the original design point, the package must be reconfigured back to the original design or suffer operation performance degradation.

Conclusions. Solar Turbines’ industrial gas turbines can accommodate a broad range of gas fuels and can operate with fuel variability of 1000 to 1350 BTU/scf Wobbe Index (LHV) without modifications and uninterrupted operation. This has been demonstrated in hundreds of applications including many applications using LNG. The key to preventing fuel quality issues in a gas turbine application is establishing a solid relationship between the equipment supplier and customer so that the correct system can be designed and installed.

Respectfully submitted,

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Director, Government Affairs

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