SOUTH TEXAS ELECTRIC COOPERATIVE, INC.

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June 7, 2013

U.S. Environmental Protection Agency, Region 6
Air Permits Section (6PD-R)
Mr. Wren Stenger, Director
Multimedia Planning and Permitting Division
1445 Ross Avenue
Suite 1200
Dallas, Texas 75202-2733

Re: Response to Completeness Determination for South Texas Electric Cooperative, Inc. Greenhouse Gas PSD Application for Red Gate Power Plant, Hidalgo County, TX

Dear Mr. Stenger:

The South Texas Electric Cooperative, Inc. (STEC) is providing this letter in response to EPA's May 14, 2013 letter regarding our Greenhouse Gas (GHG) Prevention of Significant Deterioration (PSD) construction permit application for a proposed power plant near Edinburg, Texas. The letter outlines EPA's information request for the proposed Red Gate Power Plant (Red Gate). For your convenience, EPA's comments are repeated (noted in italics) with STEC's responses following. We note in the letter it indicates the Biological Assessment and Cultural Resources Report are to be submitted, these reports were submitted to EPA Region 6 via electronic mail and CD-ROM on February 15, 2013, and Region 6 confirmed receipt the same day. Please let us know if there are any comments on these documents.

<u>EPA Request:</u>

1. *On page ES-1 of the permit application, it is stated that "STEC conducted a technology assessment to evaluate various power generation alternatives including simple-cycle combustion turbine, simple-cycle reciprocating engine, and combined-cycle combustion turbine based technologies...Of the technologies evaluated, reciprocating engines were selected as the best combination of efficiency, flexibility and cost. A simple-cycle reciprocating engine plant is composed of multiple smaller units whose dispatch can be optimized to maintain peak plant efficiency over a larger operating load range...This rapid start capability, combined with the small dispatchable unit size, minimizes part load operation and results in greater overall plant efficiency and reduced emissions."*

The emission reduction techniques proposed for this project are "energy efficient engine fired with natural gas, good combustion practices, and add-on control devices include selective catalytic reduction and oxidation catalysts." Please provide the technical assessments that were performed to evaluate power generation alternatives considered for this project. Please include the different operating scenarios evaluated, the different designs of turbines and engines, and different configuration of turbines and engines considered. Please include the reasons for elimination for each alternative evaluated and any data that evaluated the efficiencies of the turbines and engines, the amount of GHG emissions associated with each alternative and the GHG reduction levels. Provide technical data that supports the number of proposed reciprocal internal combustion engines (RICE) for this project and why this enhances energy efficiency versus the other options considered for this project. Please provide benchmark data that compares the plant energy efficiency of using 12 RICE to other power plants.

STEC Response:

STEC has determined that the electrical power requirements needed to meet the demand of their members requires an additional 220 MW to 240 MW of electrical generation in their Magic Valley service area to serve peaking loads. The potential plant sites evaluated for locating the plant did not have access to water supplies other than ground water. To provide this generation STEC evaluated several generation alternatives.

The technical screening criteria used in determining the generating alternative that best fit STEC's needs were:

- Power generation output of at least 220MW but not exceeding 240MW
- High plant efficiency over the operating range of the generators
- Generation output turndown to at least 10MW
- Quick start capability to ramp from 0% Output to 100% in 10 minutes or less
- Low water usage
- Must serve peaking loads at all times of the day and night
- Capability to serve as a "Black Start Plant" for the ERCOT system
- Performance in high ambient temperature conditions

Since the main function of the facility is to serve peaking loads, simple cycle configurations were highly considered due to their simplicity and ability to synchronize with the electrical grid and ramp up to full power quickly and to provide lower turndown capability. Table 1 "Simple Cycle Configurations" shows the types of simple cycle generating alternatives considered. The GE LMS100 does not meet the electrical output range and does not have sufficient turndown, the GE LM6000 and the P&W Swift Pac 30 do not meet the generation output turndown requirement to 10MW, and the Caterpillar G20CM34, Man 20V35/44G, GE LM2500, Siemens SGT 500, and Solar Titan 250 were not as efficient as the Wärtsilä 18V50SG over the range of operation. Not reflected in Table 1, are the effects of high ambient temperature conditions on output and efficiency. Manufacturer's ratings are typically stated at ISO conditions (59°F, sea level) whereas ambient conditions in South

Texas where the proposed facility is located can significantly exceed ISO temperature. This is significant to the technology selection process since gas turbines experience a 0.3% to 0.5% drop in output and proportional decrease in efficiency for each 1°F rise in ambient air temperature (Gas Turbine World 2013 Performance Specs 29th ed., Vol. 43, No.1, p.7). Inlet chilling used to recover the power loss imposes a significant auxiliary load that decreases the efficiency of combustion turbine alternatives. The efficiency of the reciprocating engine technology selected for the Red Gate Project does not change significantly with changes in the ambient temperature until temperatures exceed 113°F, allowing full output capacity and better efficiency to be realized year round.

Combined cycle configurations were also considered as provided in Table 2 “Combined Cycle Configurations” which shows the combined cycle generating alternatives considered. The GE LM6000 gas turbine represents one of the highest efficiency combined cycle alternatives in the size range considered for this project. Higher efficiency combined cycle alternatives exist, but are much larger than the capacity needs of this project.

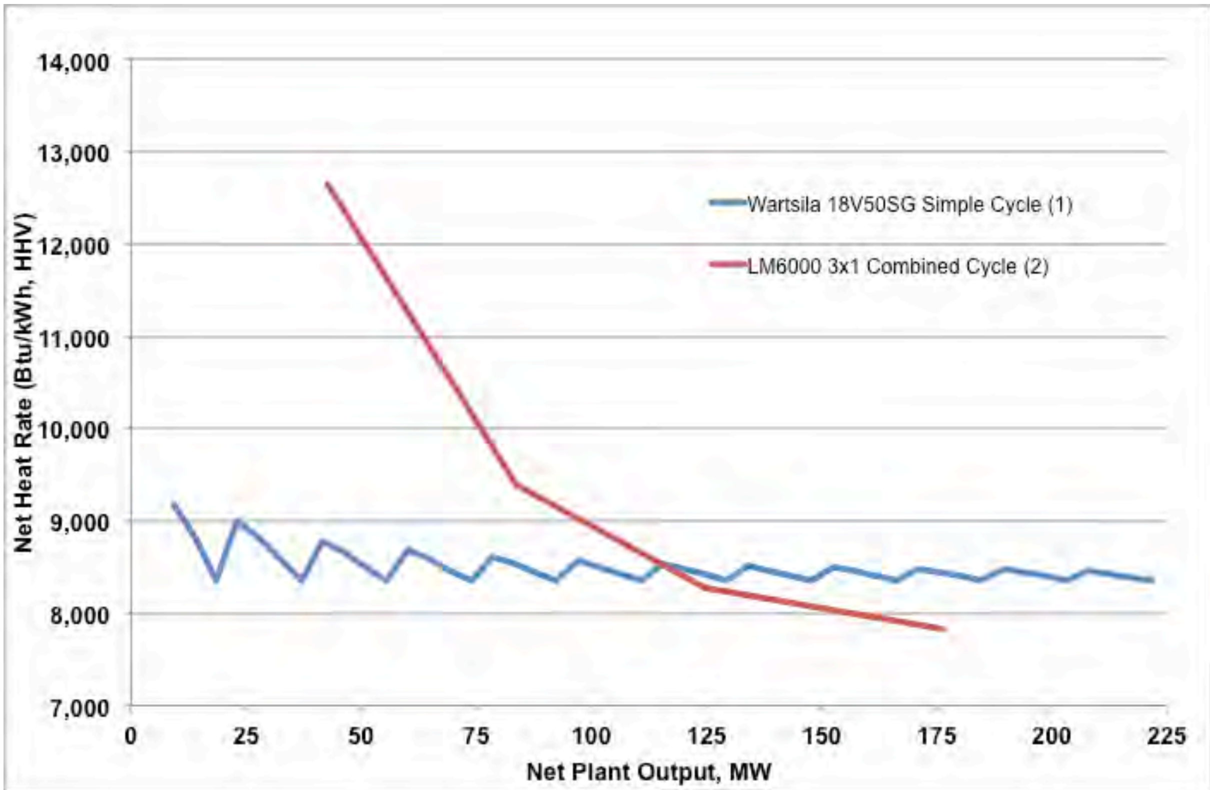
To capture the effects of ambient conditions and auxiliary load, the total plant net output and total plant net efficiencies for different loads are shown for the top simple cycle and combined cycle alternatives in Table 3 “Total Plant Comparison.” Manufacturer’s data was used for the Wärtsilä 18V50SG reciprocating engine that was selected for the project. Actual data from heat balance calculations for STEC’s Sam Rayburn 3x1 LM6000 combined cycle is shown. Although the Sam Rayburn combined cycle is slightly smaller than the minimum capacity required for the Red Gate Project, the performance is illustrative of the capabilities of the technology.

A comparison of the total plant net output versus net heat rate for the Wartsila 18V50SG in simple cycle configuration and GE’s LM6000 in combined cycle configuration is shown graphically in Figure 1. Due to the smaller incremental size of the Wartsila units and their high efficiency at part load, the Wärtsilä 18V50SG reciprocating engines maintain a large efficiency advantage on a total plant basis well past 50% total plant output.

In addition, the other considered combined cycle configurations do not meet the turndown requirements for the plant and thus were screened from further consideration. Solar and wind power generation was not considered as they do not meet the availability to provide peaking power at all times and they would not be able to provide black start capability.

Figure 1

Plant Net Heat Rate vs. Net Power Output Comparing Wärtsilä 18V50SG Simple Cycle to GE's LM6000 Combined Cycle (1)(2)



(1) From Manufacturer's Data (Wärtsilä)
(2) STEC Sam Rayburn Power Plant 3x1 Combined Cycle Heat Balance Performed by Burns & McDonnell Engineering

Table 1

Simple Cycle Configurations

Type of Generator	Engine Manufacturer	Model	Fuel	Electrical Output Per Engine/CT at Generator Terminals at ISO Conditions (MW) 100%(1)	75%	50%	Thermal Efficiency at ISO Conditions (%) 100%(1)	75%(2)	50%(2)	Number of Units Needed to Meet Output Require-ments	Total Output of Plant (MW)	CO_2e(3)(4)(5)(6)	Minimum Electrical Output (MW)(7)	Warm Start Time 0 to 100% Output
RICE	Wartsila	18V50SG	Nat Gas	18.7	14	9.4	41.1	39.4	37.7	12	224	239,479	8	10 min
RICE	Caterpillar	G20CM34	Nat Gas	10	7.5	5	40.5	38.3	36.8	24	240	259,767	4	7 min
RICE	Mann	20V35/44G	Nat Gas	10	7.5	5	39.5	37.4	35.9	24	240	266,251	4	10 min
Gas Turbine	GE	LM2500	Nat Gas	20	15	10	33.0	30.3	27.5	11	220	299,783	10	10 min
Gas Turbine	GE	LM6000	Nat Gas	45	33.75	22.5	37.9	34.7	31.6	5	225	267,114	18	10 min
Gas Turbine	GE	LMS100	Nat Gas	100	75	50	39.9	36.6	33.3	3	300	338,354	40	10 min
Gas Turbine	Siemens	SGT 500	Nat Gas	19	14.25	9.5	28.8	26.4	24.0	12	228	356,106	8	10 min
Gas Turbine	Pratt & Whitney	Swift Pac 30	Nat Gas	27	20.25	13.5	33.2	30.4	27.6	8	216	292,938	11	10 min
Gas Turbine	Solar	Titan 250	Nat Gas	22	16.5	11	35.0	32.1	29.2	10	220	282,955	9	10 min

(1) From Manufacturer's Published Data

(2) Estimated for RICE Generators from Manufacturer's Information, Estimated for Gas Turbines from EPA Document "Technology Characterization: Gas Turbines", published December 2008

(3) Based on Global Warming Factors from CFR 40 Part 98, Subpart A

(4) Based on operation at a 30% capacity factor

(5) Based on the number of Engines/CT Needed to Produce at least 220MW

(6) Does not include startup and shutdown emissions

(7) From Manufacturer's General Information

Table 2

Combined Cycle Configurations

				Electrical Output Per Engine/CT at Generator Terminals at ISO Conditions (MW)			Configuration	Thermal Efficiency at ISO Conditions (%)			Number of Units Needed to Meet Output Require-ments	Total Output of Plant (MW)	CO_2e[3][4][5][6]	Minimum Electrical Output (MW)[7]
Type of Generator	Engine Manufacturer	Model	Fuel	100%[1]	75%	50%		100%[1]	75%[2]	50%[2]				
Gas Turbine	GE	LM2500	Nat Gas	20	15	10	5 - 2x1	42.7	39.1	35.5	10	250	211,060	15
Gas Turbine	GE	LM6000	Nat Gas	45	33.75	22.5	2 - 2x1	47.3	43.3	39.4	4	240	171,459	38
Gas Turbine	Siemens	SCC-700	Nat Gas	30	22.5	15	3 - 2x1	47.3	43.3	39.4	6	222	171,459	22
Gas Turbine	Pratt & Whitney	Swift Pac 30	Nat Gas	27	20.25	13.5	3 - 2x1 plus 1x1	45.5	41.7	37.9	7	229	187,019	19

(1) From Manufacturer's Published Data

(2) Estimated for RICE Generators from Manufacturers Information, Estimated for Gas Turbines from EPA Document “Technology Characterization: Gas Turbines”, published December 2008

(3) Based on Global Warming Factors from CFR 40 Part 98, Subpart A

(4) Based on operation at a 30% capacity factor

(5) Based on the number of Engines/CT Needed to Produce at least 220MW

(6) Does not include startup and shutdown emissions

(7) From Manufacturer's General Information

Table 3

Total Plant Comparison

Type of Generator	Engine Manufacturer	Model	Fuel	Configuration	Total Plant Net Electrical Output at 94°F (MW) 100%	75%	50%	25%	Net Heat Rate at 94°F (Btu/kWh, HHV) 100%	75%	50%	25%	Minimum Electrical Output (MW)(1)(2)
RICE	Wartsila	18V50SG	Nat Gas	Simple Cycle	221.7(1)	166.3(1)	110.9(1)	55.4(1)	8,355(1)	8,355(1)	8,355(1)	8,355(1)	7.4
Gas Turbine	GE	LM6000	Nat Gas	3x1 Combined Cycle	176.3(2)	124.6(2)	83.7(2)	42.7(2)	7,821(2)	8,283(2)	9,385(2)	12,653(2)	42.7

(1) From Manufacturer's Data

(2) STEC Sam Rayburn Power Plant 3x1 Combined Cycle Heat Balance Performed by Burns & McDonnell Engineering

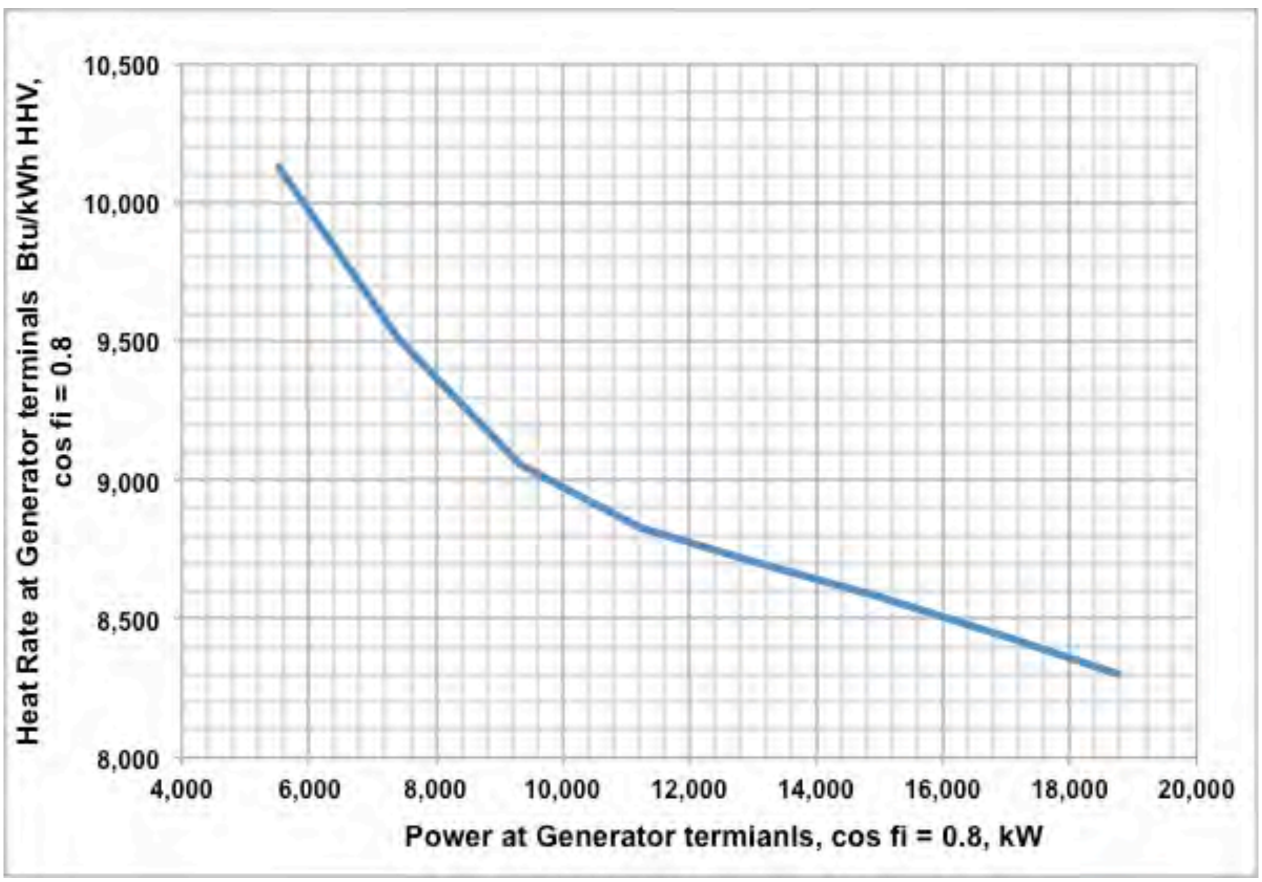
EPA Request:

2. *On page ES-2 of the permit application, it is stated that the proposed operating load range is roughly 40% to 100%. Please provide supplemental data that includes production output, gross heat rate and percent efficiency of engines being considered and please provide this data for similarly designed engines recently permitted by permitting authorities nationwide or operating internationally (this information may be represented graphically in load/efficiency curves).*

STEC Response:

Figure 2 shows heat rate and thermal efficiency as a function of power output at different output levels for the Wärtsilä 18V50SG, the engine selected for the Red Gate project. The 18V50SG is currently the highest efficiency reciprocating engine on the market.

Figure 2
Heat rate (Btu/kWh) as a function of power (gross kW) – Wärtsilä 18V50SG(1)

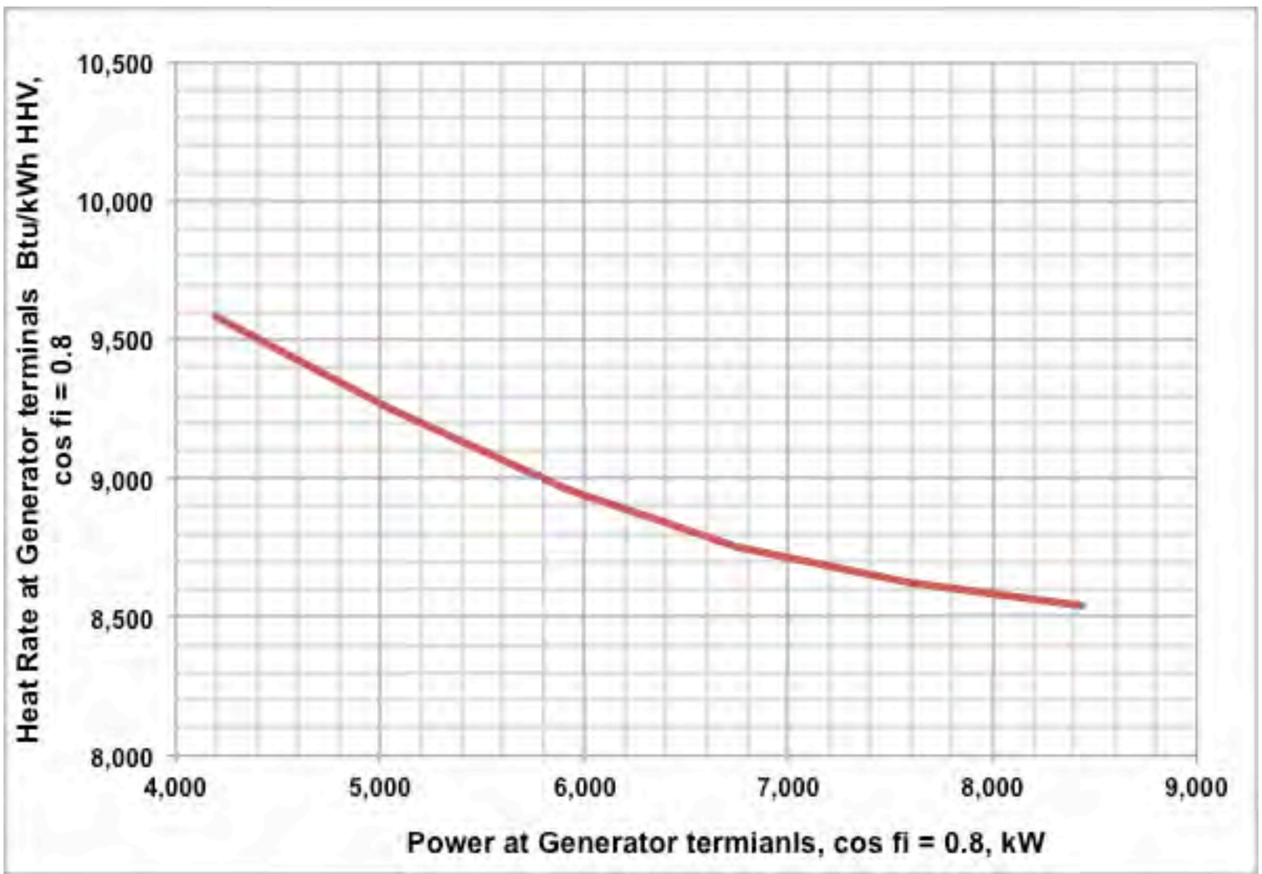


% load	40%	50%	60%	70%	80%	90%	100%
Load, kW	7,420	9,341	11,226	13,121	15,007	16,883	18,759
Btu/kWh (HHV)	9,510	9,053	8,829	8,702	8,580	8,443	8,302
% efficiency	35.9	37.7	38.7	39.2	39.8	40.4	41.1

(1) Manufacturer's data (Wärtsilä)

Figure 3 shows heat rate and thermal efficiency as a function of power output at different output levels for the Wärtsilä 20V34SG. The 20V34SG is a smaller variant of the 18V50SG utilizing a similar combustion technology and control system. STEC installed twenty-four (24) of the 20V34SG at the Pearsall Power Plant in Pearsall, Texas in 2009 and 2010. The 20V34SG were not bid for the Red Gate project due to the higher efficiency of the 18V50SG from the same manufacturer.

Figure 3
Heat rate (Btu/kWh) as a function of power (gross kW) – Wärtsilä 20V34SG(1)

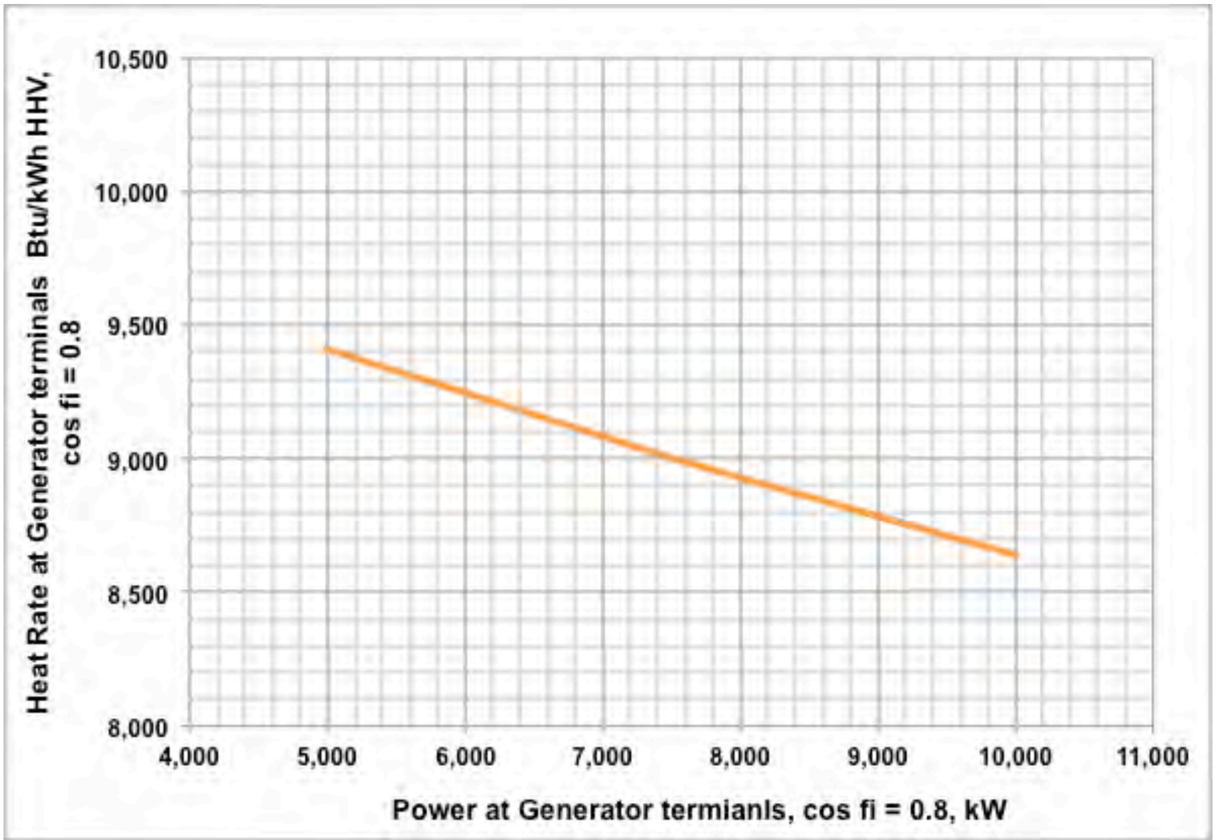


% load	50%	60%	70%	80%	90%	100%
Load, kW	4,198	5,048	5,901	6,751	7,595	8,439
Btu/kWh (HHV)	9,584	9,253	8,961	8,751	8,624	8,538
% efficiency	35.6	36.9	38.1	39.0	39.6	40.0

(1) Manufacturer's data (Wärtsilä)

Figure 4 shows heat rate and thermal efficiency as a function of power output at different output levels for the MAN 20V35/44G. The 20V35/44G is a lean-burn 4-stroke spark ignition reciprocating engine with a nominal output of 10MW. STEC included the 20V35/44G engine in the competitive bid process for the Red Gate project, but did not select the engine in part due to the higher efficiency of the Wärtsilä 18V50SG.

Figure 4
Heat rate (Btu/kWh) as a function of power (gross kW) – MAN 20V35/44G(1)(2)

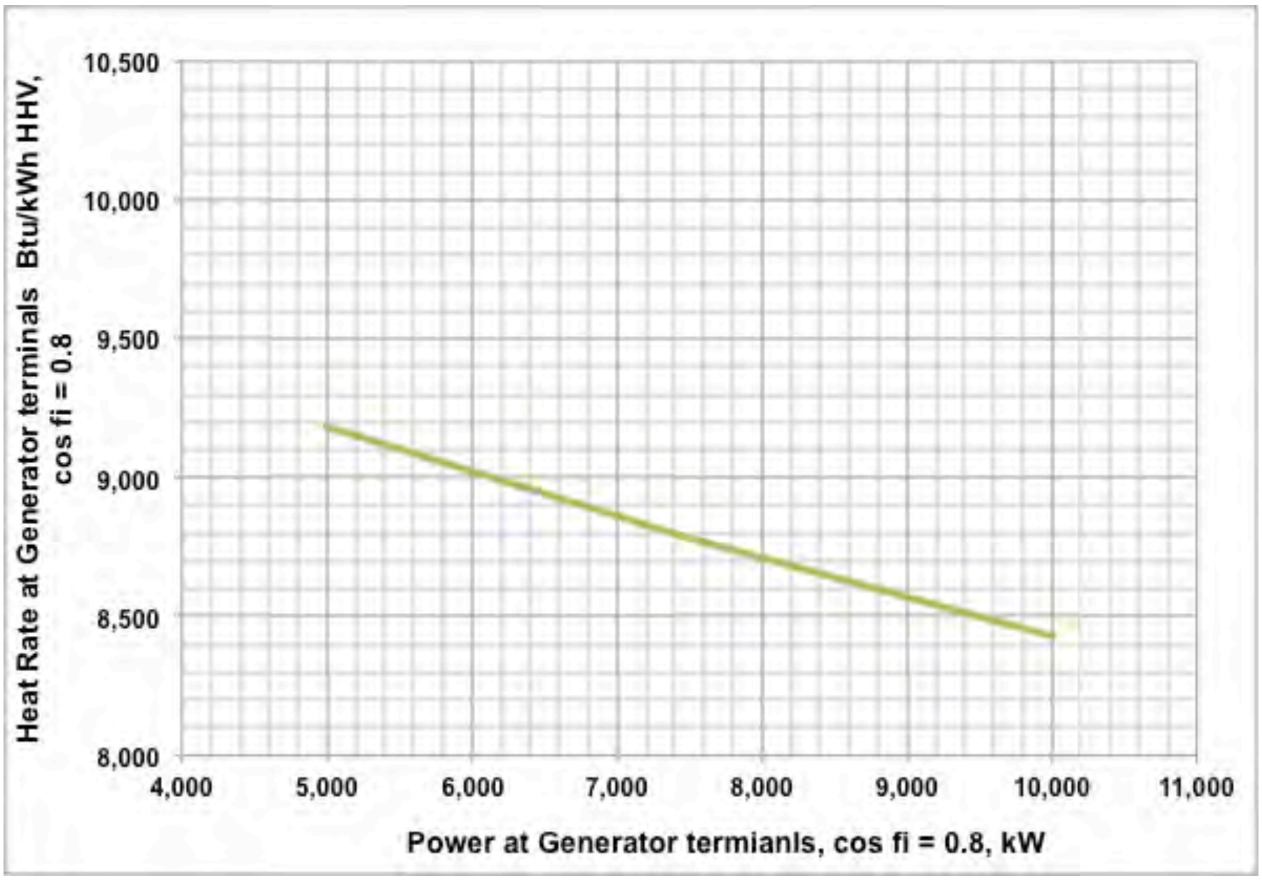


% load	50%	75%	100%
Load, kW	5,000	7,500	10,000
Btu/kWh (HHV)	9,410(1)	9,000(2)	8,640(2)
% efficiency	36.3	37.9	39.5

(1) From Manufacturer's Published Data (MAN)
(2) Estimated for RICE Generators from Manufacturers Information

Figure 5 shows heat rate and thermal efficiency as a function of power output at different output levels for the Caterpillar G20CM34. The G20CM34 is a lean-burn 4-stroke spark ignition reciprocating engine with a nominal output of 10MW. The G20CM34 is a new offering by Caterpillar, based on a similar 16-cylinder version of the same engine. The G20CM34 has not yet been put into active service. STEC included the G20CM34 engine in the competitive bid process for the Red Gate project, but did not select the engine in part due to the higher efficiency of the Wärtsilä 18V50SG.

Figure 5
Heat rate (Btu/kWh) as a function of power (gross kW) – Caterpillar G20CM34(1)(2)



% load	50%	75%	100%
Load, kW	5,000	7,500	10,000
Btu/kWh (HHV)	9,410(1)	9,000(2)	8,640(2)
% efficiency	36.3	37.9	39.5

(1) From Manufacturer's Published Data (Caterpillar)
(2) Estimated for RICE Generators from Manufacturers Information

<u>EPA Request:</u>

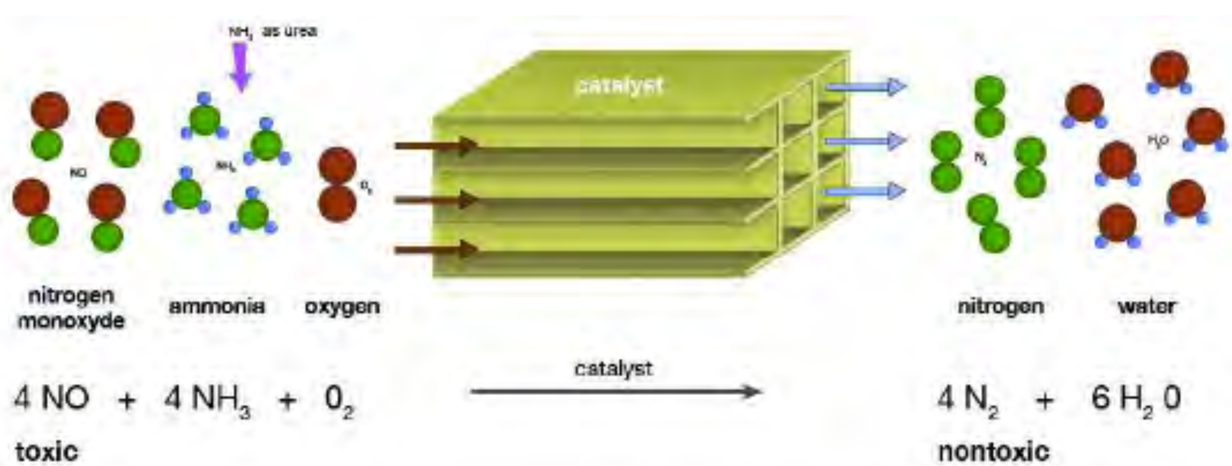
3. *On page ES-2 of the permit application, it states the proposed add-on pollution control devices to be employed by the RICE will include selective catalytic reduction (SCR) and oxidation catalyst. This is also indicated on the process flow diagram. How will the operations of the add-on technologies affect the operation of the combustion engines and thereby affect the production of GHG emissions? Please supplement the application with detailed information on the SCR and oxidation catalyst pollution control technologies to be utilized and the affect on the operation of the RICE and the amount of GHG emissions that are produced.*

<u>STEC Response:</u>

The Wärtsilä 18V50SG is able to achieve full load (maximum efficiency) at full ramp speed regardless of the starting SCR and oxidation catalyst temperature without damage to the catalyst or the need for intermediate hold-points that might affect the period needed to achieve maximum efficiency. Likewise, once the unit is in service, the SCR and oxidation catalyst will not impose any operational limitations on the unit that might increase overall GHG emissions.

The inclusion of the SCR and oxidation catalyst will not impact the amount of GHG emissions from the plant. The addition of the components will slightly increase the backpressure in the exhaust duct system, however the SCR and oxidation catalyst will be sized and designed so that this slight increase will not affect the efficiency of the engine generators and therefore not change the amount of GHG emissions produced. Figure 6 shows the SCR reaction process.

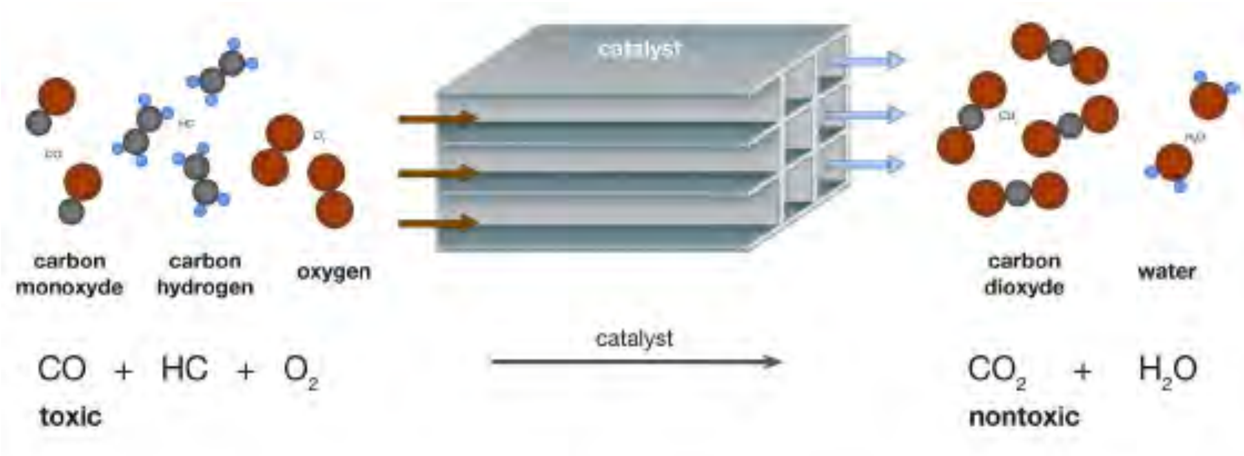
Figure 6
SCR Reaction and Impact on GHG Emissions(1)



(1) Manufacturer's data (Hüg Engineering)

The use of an oxidation catalyst for the oxidation of carbon monoxide (CO) and unburned hydrocarbons (HC) has been proposed as BACT for the Red Gate project. Although CO_2 is a byproduct of the oxidation process, the net GHG effect is difficult to determine due to the differing impacts of hydrocarbon species versus CO_2. Figure 7 shows the oxidation reaction process.

Figure 7
Oxidation Catalyst Reaction and Impact on GHG Emissions(1)



(1) Manufacturer's data (Hüg Engineering)

EPA Request:

4. *Beginning on page 1-1 of the application, it states that Red Gate will consist of 12 spark ignition (SI) RICE. In order to meet the peaking requirements of the proposed plant, the SI RICE will be operated in simple-cycle mode. The four-stroke lean burn (4SLB) natural gas-fired engines being proposed are the Wartsila 18V50SG. Please provide manufacturer design specification data sheets and comparative benchmark efficiency and/or data for these RICE to existing or similar engines.*

STEC Response:

See response to questions 1 and 2. Also see Wartsila brochure "Attachment 1 - Wärtsilä 50SG Engine Technology.pdf" for a technology description and specification sheet.

EPA Request:

5. *On page 1-2 of the application, it states that to limit the exposure of STEC member load to temporary price spikes, STEC is constructing Red Gate as a "peaking generation*

facility." However, page 3-1, Table 3, footnote 1, states that annual emissions are based on 8,760 hours of operation for the SI RICE. The characteristics of a power generating plant that has been designed to operate as a peaking facility typically include fewer operating hours and more startups/shutdowns than a power plant that has been designed to operate as a base and/or intermediate load facility. As is stated in the proposed NSPS for EGU's "the peaking season is generally considered to be less than 2,500 hours annually." (77 FR 22432). Furthermore, 40 CFR 72.2 defines a "peaking unit" as having "an average capacity factor of no more than 10.0 percent during the previous three calendar years and a capacity factor of no more than 20.0 percent in each of those calendar years." The proposed annual emission limits that are calculated based on 8,760 hours of operation for the SI RICE is substantially greater than 2500 hours annually, and also appears to be greater than either the 10 (average annual) or 20 percent (maximum annual) capacity factor in the federal definition of "peaking unit." Accordingly, please provide supplemental details on expected load shift and duration of periods of reduced generation or no load that would negatively impact STEC from selecting combined cycle turbines and/or any data/plant metrics that supports the selection of simple cycle reciprocal engines in the BACT analysis. Please also provide a calculated annual load factor for the proposed reciprocal engines.

STEC Response:

Emissions are calculated based on 8,760 hours in order to provide a conservative estimate of emissions and not restrict the annual hours of operation of the facility. "Peaking" describes the pattern of operation not the annual usage. STEC needs to be able to quickly cover the potential loss of base-load facilities due to outages as well as the summer-time peak demand. Thus predicting a consistent annual usage does not fit with the intended plant use for peaking and for supplementing base-load operation during outages of other plants. As noted in the application, emissions also include 730 start-up/shutdowns per year per engine (based on two start-up/shutdowns per day per engine), thus reflecting the expected rapid start, peaking operation. There are several factors that support the use of RICE for this facility, not just the rapid start and operation flexibility, but the ability to dispatch much smaller incremental power output more efficiently than with a combined cycle turbine. Even small combined cycle turbines do not have the turndown capability to meet the anticipated lower electrical outputs of 10 MW or less.

The anticipated annual load factor will vary from year to year based on market conditions, STEC's member load requirements, the disposition of STEC's other generation resources, grid reliability requirements, and other factors. The term "peaking" was used to broadly characterize the role of the units in STEC's generation portfolio, and their purpose of meeting temporary spikes in demand for electricity. There may be periods where the proposed plant would not meet the definition of "peaking unit" as set forth in 40 CFR 72.2, either exceeding or falling short of the capacity factors listed. Although the emissions are calculated on an 8,760-hour basis, the impact of multiple starts, consistent with peaking or intermediate operation was reflected in the permit application.

Although it is unlikely the facility will be “base loaded,” STEC felt it prudent to not artificially limit the dispatch of the units and limit the flexibility of the resource if the resource could be permitted for continuous operation under the applicable regulations. Furthermore, the market design allows usage of the units to provide services that benefit STEC’s members while the units are shutdown. One example of this would be the non-spinning reserve ancillary service, where STEC may receive compensation for being ready to come online and produce power within a specified timeframe. Limiting the hours of operation could take away from this capability, without additional environmental benefit.

Changes in the ERCOT market design to optimize economic dispatch while maintaining grid reliability play an increasingly significant role in the dispatch of flexible peaking generation like that proposed for the Red Gate facility. Units are frequently called upon by ERCOT for voltage support, frequency stabilization, and to alleviate transmission congestion. Demand for flexible generation with quick start and fast ramp capabilities has further increased due to increasing amounts of wind and other non-dispatchable renewable capacity installed within ERCOT. These market forces make it difficult to predict the capacity factor the plant will be dispatched over any particular period of time.

<u>EPA Request:</u>

6. *On page 3-1 of the permit application, it states that "There is effectively no cold start from a stand-by perspective, because during start-up electric heaters are used to circulate warm water until the engine block reaches a temperature sufficient to allow start-up, which is roughly 125°F.” Did you consider using a combined cycle unit that would provide the same effect without the additional power requirements? If so, why was this option eliminated?*

<u>STEC Response:</u>

Continuous electric heating of the cooling water while the engines are off-line allows the engine to achieve very quick (<10 minute) start to full load times. If the engine cooling water was not kept continuously heated, startup times would be greatly extended to periods of several hours depending on ambient conditions. The size and thickness of the engine block mandate that a minimum block temperature of 122°F be achieved prior to initiation of a start to prevent potentially damaging thermal stresses during a start. For this reason, some standby heat source must be available with the engine shutdown. Between 122°F and 158°F in the high temperature cooling loop, a start may be initiated, but the unit will be derated until sufficient temperature is achieved. Although waste heat could be recovered during startup to raise the cooling water temperatures from 122°F to 158°F this would extend the startup time significantly and seriously impair the ability of the units to respond to the frequent fluctuations in demand present on the grid and within STEC’s member load profile.

Collection and utilization of waste heat through a combined cycle heat recovery boiler for storage and subsequent offline heating of the engine cooling water is impractical due to frequent shutdowns associated with peaking operation.

The use of standby power is minimized through thermostatic control of the electric heating and segregating the high temperature (HT) and low temperature LT cooling loops.

EPA Request:

7. *STEC did not propose to implement a fugitive emission monitoring program for piping components. Please provide supplemental data to the 5-step BACT analysis for fugitives that include a comprehensive evaluation of the technologies considered to reduce fugitive emissions and a basis for elimination, or information detailing why fugitive emissions will not be emitted from this project. The technologies could include, but are not limited to, the following:*

    - *Installing leakless technology components to eliminate fugitive emission sources;*
    - *Implementing an alternative monitoring program using a remote sensing technology such as infrared camera monitoring;*
    - *Designing and constructing facilities with high quality components and materials of construction compatible with the process known as the Enhanced LDAR standards;*
    - *Monitoring of flanges for leaks;*
    - *Using a lower leak detection level for components; and*
    - *Implementing an audio/visual/olfactory (AVO) monitoring program for compounds.*

    The BACT analysis should include for the proposed monitoring program a compliance strategy. (i.e., frequencies of inspections, maintenance repair strategy, recordkeeping, etc.).

STEC Response:

The natural gas pipeline will be routed underground to the plant site. Also within the Red Gate site the natural gas pipeline will be routed mostly underground utilizing welded joints, except within the gas yard and immediately outside the two engine hall buildings where flange connections are required to allow for maintenance on equipment. In 40 CFR Part 98, Subpart W, emission factors in Table W-1A are only provided for "components," which are defined as each metal to metal joint or seal of non-welded connection separated by a compression gasket…" Also per TCEQ's Technical

Supplement 3: Equipment Leak Fugitives, a 100% control credit may be taken for connections that are welded together around the circumference.

The two main natural gas pipelines emerge from underground immediately outside the two engine hall buildings. Inside the engine halls, the pipeline is divided into six supply lines, one to each engine. It is noted that due to the low pressure requirements of the engines, no gas compressors will be required. The pipeline component quantities were estimated which includes components in the gas yard and inside and outside the engine hall buildings. These component quantities were used to estimate the fugitive emissions, which are roughly 0.02% of facility CO_2e emissions. The emissions from natural gas fugitives (emission point NGFUG) were estimated using component emission factors from 40 CFR 98, Table W-1A, component counts, and typical natural gas composition (see Attachment 2 – Emissions from Natural Gas Fugitives.pdf). Our estimate also includes fugitive emissions from gaseous fuel venting during engine shutdown/maintenance and small equipment repair/maintenance, as shown in Attachment 2 at less than 1 tpy CO_2e these emissions are negligible.

As part of the fuel regulator system provided by Wartsila there is an automatic check that can determine if there are natural gas leaks. Before each start-up of an engine the system conducts an automatic check of pressure drop across fuel regulator skid. Thus on every start-up (given the number of start-up/shutdowns per year this could be occurring several times a day) there is a permissive to allow the start to continue only if no gas leak is indicated.

LDAR programs have traditionally been utilized to control VOC emissions, and the Red Gate facility is not subject to any regulations requiring an LDAR program, thus any monitoring would be done solely for GHG emissions from natural gas fugitives. Based on the TCEQ document "*Control Efficiencies for TCEQ Leak Detection and Repair Programs*" dated July 2011, for components in gas service the 28LAER and Audio/Visual/Olfactory (AVO) programs have equivalent control credits (97%) for odorous compounds, such as odorized natural gas. Because natural gas is odorized, specifically to enable the detection of leaks, leaking components especially within the engine hall buildings should be discoverable through olfactory means. As part of the Red Gate project, STEC will implement an AVO program for natural gas fugitives from piping components involving walk-through inspections at least monthly. In addition, key operational personnel will be trained to utilize AVO to monitor for leaks during routine plant operations and round checks. Any leaks discovered will be repaired as quickly as practicable.

EPA Request:

8. *What are the proposed recordkeeping requirements for the combustion engines operating parameters? How will the air/fuel ratio be assured during operation of the combustion engines, i.e., alarms, alerts, continuous monitoring, etc? Will O_2 or CO_2 analyzers be*

utilized? What will be the target ratio? Please provide more details of what operating parameters will be monitored to ensure equipment is operating at the design efficiency.

STEC Response:

The Wärtsilä 18V50SG engine operates on 4-stroke spark ignition cycle utilizing lean-burn technology. Lean-burn engines utilize more air than is necessary for complete combustion to reduce NO_x emissions and increase efficiency (lower CO_2). Under lean-burn conditions, precise control of spark timing and air/fuel ratio are necessary to prevent knocking (pre-ignition) or misfiring conditions. This precise control is accomplished through the utilization of a pre-chamber where a smaller portion of the total air/fuel mixture is ignited by the spark. Independent control of admission of gas to the pre-chamber and release of the ignited air fuel mixture into the cylinder ensure optimization of main cylinder combustion. The Wärtsilä 18V50SG engines utilize independent control by cylinder of all fuel admission and spark timing. The turbocharger wastegate valve controls the air/fuel ratio within a narrow window based on load and real-time site conditions. Feedback to optimize combustion is provided by cylinder specific exhaust gas temperature sensors, knock sensors, and cylinder pressure sensing along with other engine and environmental measurements on a continuous basis. This ensures that optimum combustion is achieved automatically across a wide range of conditions without re-tuning the engine. The actual target air/fuel value changes based on the current conditions and feedback from the control system sensors. The target value is approximately 2.1:1.

If knocking or misfiring in a cylinder causes incomplete combustion that normal adjustment of engine parameters cannot correct, the control system will automatically shutdown the cylinder and curtail engine output to prevent engine damage or excess emissions. If multiple cylinders are shutdown the entire engine is automatically shutdown and the conditions must be remedied before startup. All operational parameters are made available to the control room operator though real-time displays and alarming so that proper corrective action can be taken in the event of a malfunction. These values are logged for further trending and analysis to detect and prevent future conditions that may adversely affect the efficiency of the unit. Multiple cylinders per unit and multiple units in the facility allow for quick detection of abnormal parameters.

EPA Request:

9. *Please provide the supporting calculations for the proposed BACT output-based limit of 1193 lb CO2/MWh and the basis to support the rationale used to derive the limit.*

STEC Response:

The proposed BACT output-based limit is based on the lb CO_2/MWh emissions provided by Wartsila plus 9% margin to account for degradation, variation among machines, and variation in conditions versus design values, which is consistent with other GHG permits. As BACT is to be applicable over all load levels (not just at full load), the lb CO_2/MWh emission factor accounting for the expected load range is used as follows:

$$1095 \frac{\text{lb } CO_2}{\text{MWh}} \times 1.09 = 1193 \frac{\text{lb } CO_2}{\text{MWh}}$$

EPA Request:

10. *BACT is a case-by-case determination. Please provide site-specific facility data to evaluate and eliminate carbon capture storage (CCS) from consideration. This material should contain detailed information on the quantity and concentration of CO_2 that is in the waste stream and the equipment for capture, storage and transportation. Please include cost of construction, operation and maintenance, cost per pound of CO_2 removed by the technologies evaluated and include the feasibility and cost analysis for storage or transportation for these options. Please discuss in detail any site specific safety or environmental impacts associated with such a removal system.*

STEC Response:

While a cost evaluation is not consistent with other EPA Region's treatment of simple cycle projects, as requested an estimate for a hypothetical CCS system is included. As provided on page 5-3 of the application, the CO_2 concentration in the SI RICE exhaust is roughly 4.5 vol-% and this low dilute concentration presents challenges for separating CO_2. Per the EPA Region 9 BACT evaluation for the Pio Pico Energy Center "…it would essentially require conversion of the turbines from simple-cycle to combined-cycle operation. Therefore, based on this information, we conclude that while carbon capture with an MEA absorption process is feasible for a combined-cycle operation, it is not feasible for simple-cycle units (i.e., those without a HRSG.)" Consequently, in order to estimate costs for CCS applied at Red Gate several assumptions need to be made:

- The simple-cycle facility needs to be converted into combined-cycle with the addition of HRSG, wet or dry cooling, and auxiliary equipment.
- For wet cooling, which would allow the plant to operate more efficiently, a source for a substantial amount of water would need to be found that is not part of the current project. Given the arid climate of south Texas, installing a major water consuming process goes against prevailing water conservation measures. In order to provide a cost estimate, it is assumed the City of Edinburg could provide the needed process water.
- A long-term (Red Gate minimum 30 year life) storage facility capable of handling the high-volume, yet intermittent in flow, CO_2 stream would need to be found. Construction of a new pipeline would be needed to transport the CO_2 stream, including obtaining rights-of-way and avoidance of any sensitive areas to minimize

impacts on the environment. The length of such a pipeline is uncertain given the myriad factors for identifying a viable, long-term storage facility. In order to provide a cost estimate, a pipeline length of 40 miles is used assuming storage could be obtained at “Candidate EOR reservoir(s)” in Starr County as identified in the NETL Atlas IV, ARRA Site Characterization Projects section, p.109 (see http://www.netl.doe.gov/technologies/carbon_seq/refshelf/atlasIV/index.html).

Several documents from the U.S. Department of Energy National Energy Technology Laboratory (NETL) were used as references for estimating the cost of CCS at Red Gate. The following table outlines the costs to implement CCS to the Red Gate project:

Component	**Cost**
Conversion to CC	$41,870,000[1]
Cost of Process Water (annual)	$450,000[2]
CO_2 Capture[3]	$185,460,000 plus annual O&M costs
CO_2 Transport[4]	$46,160,336 plus $338,160 annual O&M costs
CO_2 Storage and Monitoring[5]	$51,510,000
TOTAL	$325,450,336

(1) Preliminary estimate provided by Wartsila for 12 engine combined cycle plant.

(2) Based on increased water withdrawal rates in NETL “*Cost and Performance Baseline for Fossil Energy Plants*, Volume 1: Bituminous Coal and Natural Gas to Electricity,” Revision 2, November 2010, Exhibit 5-27 for NGCC with and without CCS (4.1 gpm/MW_{net}) and a 30% capacity factor for usage of 142 million gallons per year, and water rates from the City of Edinburg.

(3) Based on difference in $/kW for NGCC with and without CCS ($843/kW, Case 14 – Case 13) in NETL “*Cost and Performance Baseline for Fossil Energy Plants*, Volume 1: Bituminous Coal and Natural Gas to Electricity,” Revision 2, November 2010, and 220,000 kW.

(4,5) Based on NETL Quality Guidelines for Energy Systems Studies calculations, see below for details.

CO_2 transport and storage costs are based on the NETL Quality Guidelines for Energy Systems Studies, “*Carbon Dioxide Transport and Storage Costs in NETL Studies*,” Final Report March 14, 2013 (DOE/NETL-2013/1614), which is available at the following web address:

http://www.netl.doe.gov/energy-analyses/pubs/QGESS_CO2T%26S_Rev2_20130408.pdf

Pipeline diameter and length is conservatively assumed at 8” and 40 miles, and costs are not adjusted from 2011 dollars.

Pipeline Capital Costs		
Component	**Equation, D = diameter (in), L = length (mi)**	**Cost**
Materials	$70,350 + $2.01 x L x (330.5 x D^2 + 686.7 x D + 26,960)	$4,380,240
Labor	$371,850 + $2.01 x L x (343.2 x D^2 + 2,704 x D + 170,013)	$17,140,862
Miscellaneous	$147,250 + $1.55 x L x (8,417 x D + 7,234)	$21,469,918
Right-of-way	$51,200 + $1.28 x L x (577 x D + 29,788)	$1,812,685
Other Capital Costs		
CO_2 Surge Tank	Units = $	$1,244,724
Pipeline Control System	Units = $	$111,907
Pipeline O&M Costs		
Fixed O&M	$8,454 x mile/year	$338,160/year

Storage and monitoring costs are based on the East Texas storage cost in Table 9 of $6.06 per ton CO_2 (2011 dollars) and an assumed annual capacity factor of 30%, a 30-year life, and 90% capture for cumulative capture of approximately 8.5 million tons CO_2.

Based on the calculations above the estimated cost for CCS at Red Gate is over $325,000,000. The estimated capital cost of the project is $200 million. The cost of CCS is more than the cost of the facility, without even accounting for the energy penalty and additional CO_2 and criteria pollutant emissions from the required additional fuel usage, thus implementing CCS would make the project infeasible. As discussed above, even if a method of separation could be applied to the process, in addition to using over 3800 times the water, collateral impacts from the energy penalty to operate such a system and potential damage to the environment from the infrastructure required to transport and store the CO_2 stream (pipeline, potential groundwater impacts from carbon sequestration, impacts to wildlife from pipeline construction) are significant.

The estimated cost of electricity for the planned simple cycle plant is $92.83/MWh. The cost of electricity for the plant with CCS increases to $173.00/MWh based on converting to combined cycle, adding carbon capture equipment, transportation, and storage. Therefore the cost to add CO_2 capture would nearly double the cost of electricity, which would result in the plant not being dispatched into the market due to the high cost of the electricity.

We are eager to work with EPA Region 6 personnel to ensure the review of our application moves forward efficiently. Please contact me at japackard@stec.org or 361.485.6320 if you have any questions or need additional information.

Sincerely,

John Packard

John Packard
Manager of Generation

Attachments

Cc: Melanie Magee, EPA
Mike Lehr, SAIC
Andrea Adams, SAIC

Attachment 1

Wärtsilä 18V50SG Engine Technology

WÄRTSILÄ **Engines**

WÄRTSILÄ 50SG ENGINE TECHNOLOGY

WÄRTSILÄ Engines

WÄRTSILÄ 50SG ENGINE TECHNOLOGY

This is a brief guide to the technical features and performance of the Wärtsilä 50SG engine.

DESIGN PHILOSOPHY

The Wärtsilä 18V50SG was developed in response to the market need for larger gas engines. Its design principles are based on the well-proven technology of the Wärtsilä 34SG and Wärtsilä 50DF gas engines. The Wärtsilä 50SG lean-burn gas engine utilises the frame of the Wärtsilä diesel/heavy fuel engine with its advanced integrated lube oil and cooling water channels. The bore is 500 mm and it maximises the power potential of the engine block.

The Wärtsilä 50SG meets current and future requirements for the overall cost of ownership. It is designed for flexible manufacturing methods and long maintenance-free operating periods. The engine is fully equipped with all essential ancillaries and a thoroughly planned interface to external systems.

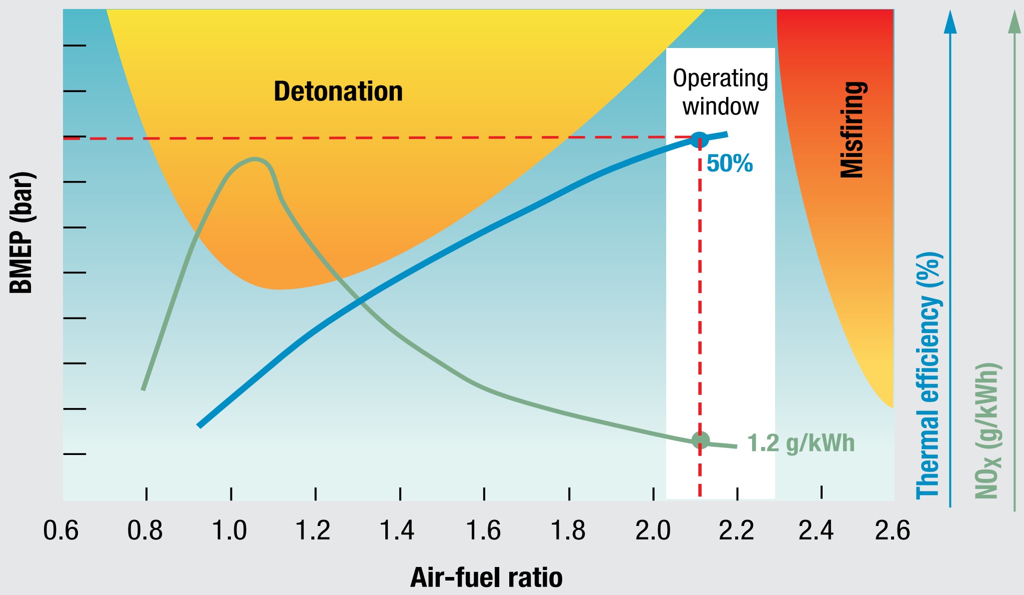
The Wärtsilä 50SG combines high efficiency with low emissions. This is achieved by applying state-of-the-art technology with features including:

- Use of a lean gas mixture for clean combustion
- Individual cylinder combustion control and monitoring, providing even load on all cylinders
- Stable combustion, ensured by a high-energy ignition system and pre-combustion chamber
- Self-learning and self-adjustable functions in the control system
- Minimal consumables.

In 1992, Wärtsilä started the development of lean-burn, spark-ignited Otto gas engines. The first WÄRTSILÄ® SG engine was released in 1995 and now the product range of lean-burn gas engines has been expanded by introducing the new Wärtsilä 50SG. These engines take the power output of the Wärtsilä 50SG series up to 18 MW.

The Wärtsilä 50SG is a four-stroke, spark-ignited gas engine that works according to the Otto process and the lean-burn principle. The engine has ported gas admission and a prechamber with a spark plug for ignition.

The engine runs at 500 or 514 rpm for 50 or 60 Hz applications and produces 18,810 and 19,260 kW of mechanical power, respectively. The efficiency of the Wärtsilä 50SG is the highest of any spark-ignited gas engine today. The natural gas fuelled, lean-burn, medium-speed engine is a reliable, high-efficiency and low-pollution power source for flexible baseload, intermediate peaking and combined cycle plants.



THE LEAN-BURN CONCEPT

In a lean-burn gas engine, the mixture of air and gas in the cylinder is lean, i.e. more air is present in the cylinder than is needed for complete combustion. With leaner combustion, the peak temperature is reduced and less NO_X is produced. Higher output can be reached while avoiding knocking and the efficiency is increased as well, although a too lean mixture will cause misfiring.

Ignition of the lean air-fuel mixture is initiated with a spark plug located in the prechamber, a high-energy ignition source for the main fuel charge in the cylinder. To obtain the best efficiency and lowest emissions, every cylinder is individually controlled to ensure operation at the correct air-fuel ratio and with the correct timing of the ignition.

Stable and well-controlled combustion also reduces the mechanical and thermal load on engine components. The specially developed Engine Control System is designed to control the combustion process in each cylinder, and to keep the engine within the operating window by optimising the efficiency and emissions level of each cylinder under all conditions.

LOW EMISSIONS

The main parameters governing the rate of NO_X formation in internal combustion engines are peak temperature and residence time. The temperature is reduced by the combustion chamber air-fuel ratios: the higher the air-fuel ratio the lower the temperature and consequently the lower the NO_X emissions.

In the Wärtsilä 50SG engine, the air-fuel ratio is very high and stays uniform throughout the cylinder, due to the premixing of fuel and air before introduction into the cylinders.

Maximum temperatures and subsequent NO_X formation are therefore low, since the same specific heat quantity released by combustion is used to heat up a larger mass of air.

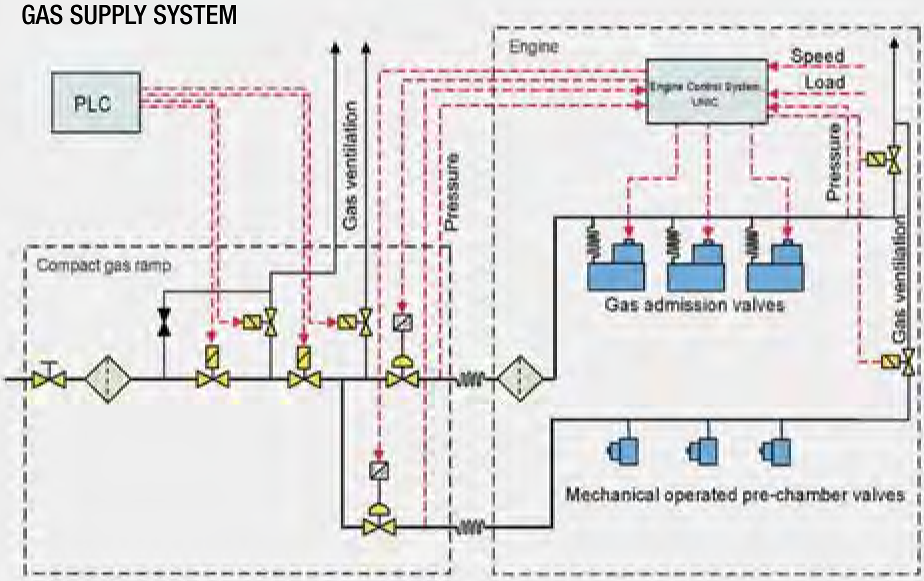
Benefiting from this unique feature of the lean-burn principle, the NO_X emissions from the Wärtsilä 50SG are extremely low.

GAS SUPPLY SYSTEM

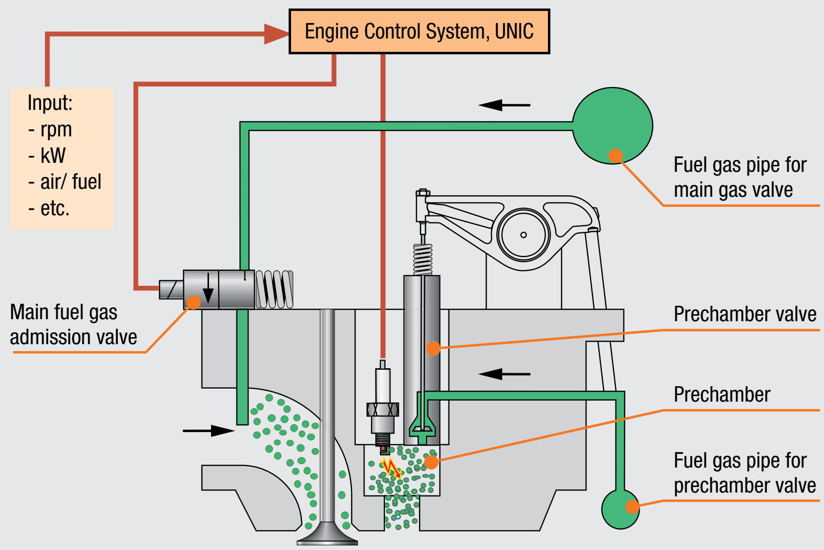
Before the natural gas is supplied to the engine, it passes through a gas-regulating unit, including filter, pressure regulators, shut off valves and ventilating valves. The external pressure regulator regulates the gas pressure to the correct value under different loads; however, the maximum pressure needed is not more than 4.5 bar(g) at full load.

In the engine, the gas is supplied through header pipes running along the engine, continued with individual feed pipes to each main gas admission valve located on each cylinder head. There are two header pipes per bank, one for the main and one for the prechamber gas supply. A filter is placed before every gas admission valve to prevent particles from entering the valve.

GAS SUPPLY SYSTEM



GAS ADMISSION SYSTEM



GAS ADMISSION VALVE

GAS ADMISSION SYSTEM

The Wärtsilä 50SG engine fully controls the combustion process in each cylinder. The "brain" controlling the combustion process and the whole engine is the Engine Control System.

The gas admission valves located immediately upstream of the inlet valve are electronically actuated and controlled to feed the correct amount of gas to each cylinder. Since the gas valve is timed independently of the inlet valve, the cylinder can be scavenged without risk of the gas escaping directly from the inlet to the exhaust. Various parameters such as engine load, speed and cylinder exhaust temperatures are monitored and work as inputs to the Engine Control System. With this arrangement, each cylinder always works within the operating window for the best efficiency at the lowest emission levels.

The ported gas admission concept provides:

- High efficiency
- Good load response
- Lower thermal loading of engine components
- No risk of backfire to the air inlet manifold.

The Aksa Samsun power plant in Turkey is equipped with the first Wärtsilä 18V50SG generating set with a total electrical output of 18.3 MW.

PRECHAMBER

The prechamber is the ignition source for the main fuel charge and is one of the essential components of a lean-burn spark-ignited gas engine.

The prechamber should be as small as possible to give low NO_X values, but big enough for rapid and reliable combustion. Some of the design parameters considered are:

- Shape and size
- Mixing of air and fuel
- Gas velocities and turbulence at the spark plug
- Cooling of the prechamber and the spark plug
- Choice of material.

The prechamber of the Wärtsilä 50SG is already optimised at the design stage using advanced three-dimensional, computerised fluid dynamics. In practice, the results can be seen as:

- Reliable and powerful ignition
- High combustion efficiency and stability
- Extended spark plug life
- Very low NO_X levels.

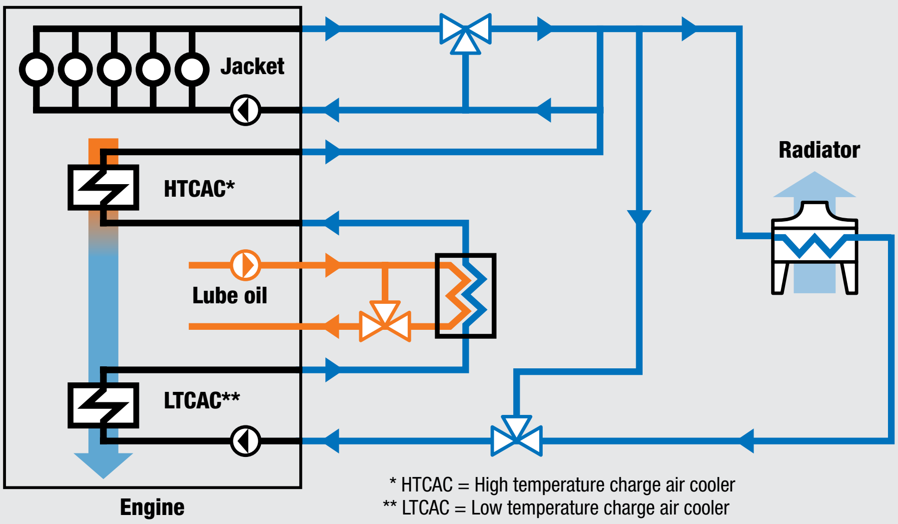
Gas is admitted to the prechamber through a mechanical, hydraulic-driven valve. This solution has proved to be extremely reliable and results in an excellent mixture in the prechamber.

IGNITION SYSTEM

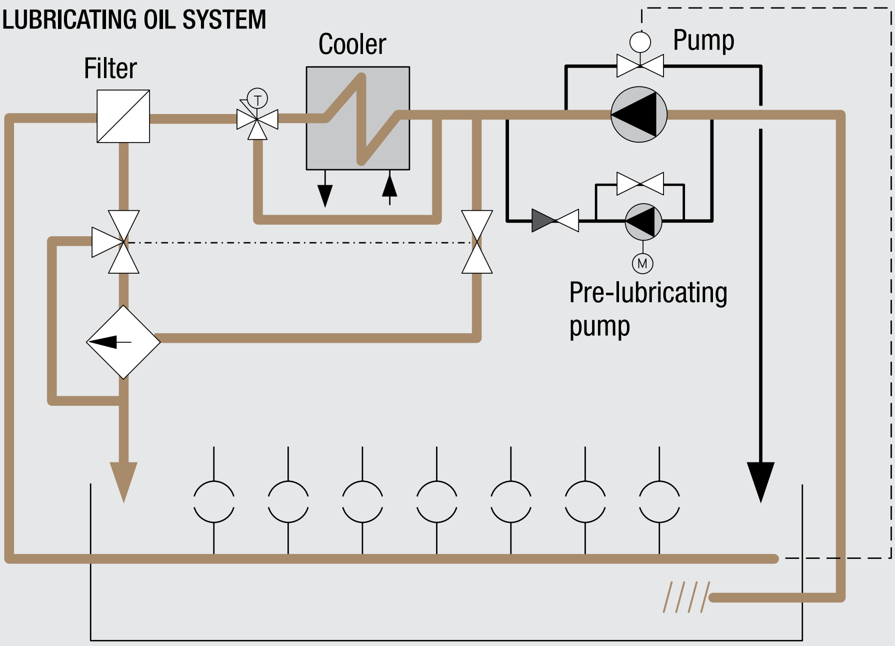
The Wärtsilä 50SG ignition system is tailor-made for the engine type and integrated in the Engine Control System. The ignition module communicates with the main control module, which determines the global ignition timing. The ignition module controls the cylinder-specific ignition timing based on the combustion quality. The cylinder-specific control ensures the optimum combustion in every cylinder with respect to reliability and efficiency.

The ignition coil is located in the cylinder cover and is integrated in the spark plug extension. The coil-on-plug design ensures a reliable solution with a minimum of joints between the spark plug and the ignition coil. The spark plug has been especially developed for long lifetime and to withstand the high cylinder pressure and temperature related to the high engine output.

COOLING SYSTEM



LUBRICATING OIL SYSTEM



The LTCA cooling circuit and jacket cooling circuit have water pumps integrated in the cover module at the free end of the engine coolers and the water temperature out from the jacket cooling circuit is controlled by external thermostatic valves.

The default cooling system is a single-circuit radiator cooling system where the cooling circuits on the engine are connected in series. For heat recovery applications each cooler can be individually connected to an external cooling system. The open interface allows full freedom in cooling and heat recovery system design.

AIR-FUEL RATIO

To always ensure correct performance of the engine, it is essential to have the correct air-fuel ratio under all types of conditions. The Wärtsilä 50SG uses an exhaust gas wastegate valve to adjust the air-fuel ratio. Part of the exhaust gas bypasses the turbocharger through the wastegate valve. This valve adjusts the air-fuel ratio to the correct value regardless of varying site conditions under any load.

WASTEGATE

A wastegate is installed next to the turbocharger turbine to provide optimal charge air pressure and turbine speed.

STARTING SYSTEM

The Wärtsilä 50SG engine is provided with pneumatic starting valves in the cylinder heads of one bank. The valves are operated by air from a distributor at the end of the camshaft. A starting limiter valve prevents the engine from starting if the turning gear is engaged.

COOLING SYSTEM

The Wärtsilä 50SG engine is designed with a Wärtsilä open-interface cooling system for optimal cooling and heat recovery. The system has four cooling circuits: the cylinder cooling circuit (jacket), the charge air low temperature (LTCA) and high temperature (HTCA) cooling circuits, and the circuit for the lube oil cooler (LO) built on the auxiliary module.

LUBRICATING OIL SYSTEM

The Wärtsilä 50SG has an engine-driven oil pump and is provided with a wet sump oil system. On the way to the engine, the oil passes through a full-flow automatic filter unit and a safety filter for final protection. Lubricating oil is filtered through a full-flow automatic back flushing filter. A separate dupplex filter in the back flushing line acts as an indicator of excessive dirt in the lubricating oil. A separate pre-lubricating system is used before the engine is started in order to avoid engine wear. For initial startup of a new engine, provision has been made for mounting special running-in filters in front of each main bearing.

PISTON

Pistons are of the low-friction, composite type with forged steel top and aluminium skirt. The design itself is tailored for an engine of this size and includes a number of innovative approaches. Long lifetime is obtained through the use of Wärtsilä's patented skirt-lubrication system, a piston crown cooled by "cocktail-shaker" cooling, induction hardened piston ring grooves and the low-friction piston ring.

PISTON RING SET

The two compression rings and the oil control ring are located in the piston crown. This three-ring concept has proved its efficiency in all Wärtsilä engines. In a three-pack, every ring is dimensioned and profiled for the task it must perform. Most of the frictional loss in a reciprocating combustion engine originates from the piston rings. A three-ring pack is thus optimal with respect to both function and efficiency.

CYLINDER HEAD

Wärtsilä successfully employs four-screw cylinder head technology. At high cylinder pressure it has proved its superiority, especially when liner roundness and dynamic behaviour are considered. In addition to easier maintenance and reliability, it provides freedom to employ the most efficient air inlet and exhaust outlet channel port configuration.

A distributed water flow pattern is used for proper cooling of the exhaust valves, cylinder head flame plate and the prechamber. This minimises thermal stress levels and guarantees a sufficiently low exhaust valve temperature. Both inlet and exhaust valves are fitted with rotators for even thermal and mechanical loading.

CYLINDER LINER AND ANTI-POLISHING RING

The cylinder liner and piston designs are based on Wärtsilä's extensive expertise in tribology and wear resistance acquired over many years of pioneering work in heavy-duty diesel engine design. An integral feature is the anti-polishing ring, which reduces lube oil consumption and wear. The bore-cooled collar design of the liner ensures minimum deformation and efficient cooling. Each cylinder liner is equipped with two temperature sensors for continuous monitoring of piston and cylinder liner behaviour.

GAS ENGINE PISTON

CYLINDER HEAD

CYLINDER LINER

CONNECTING ROD AND BIG-END BEARINGS

The connecting rod is designed for optimum bearing performance. It is a three-piece design, in which combustion forces are distributed over a maximum bearing area and relative movements between mating surfaces are minimised. Piston overhaul is possible without touching the big-end bearing and the big-end bearing can be inspected without removing the piston.

The three-piece design also reduces the height required for piston overhauling. The big-end bearing housing is hydraulically tightened, resulting in a distortion-free bore for the corrosion-resistant precision bearing. The three-piece connecting rod design allows variation of the compression ratio to suit gases with different knocking resistance.

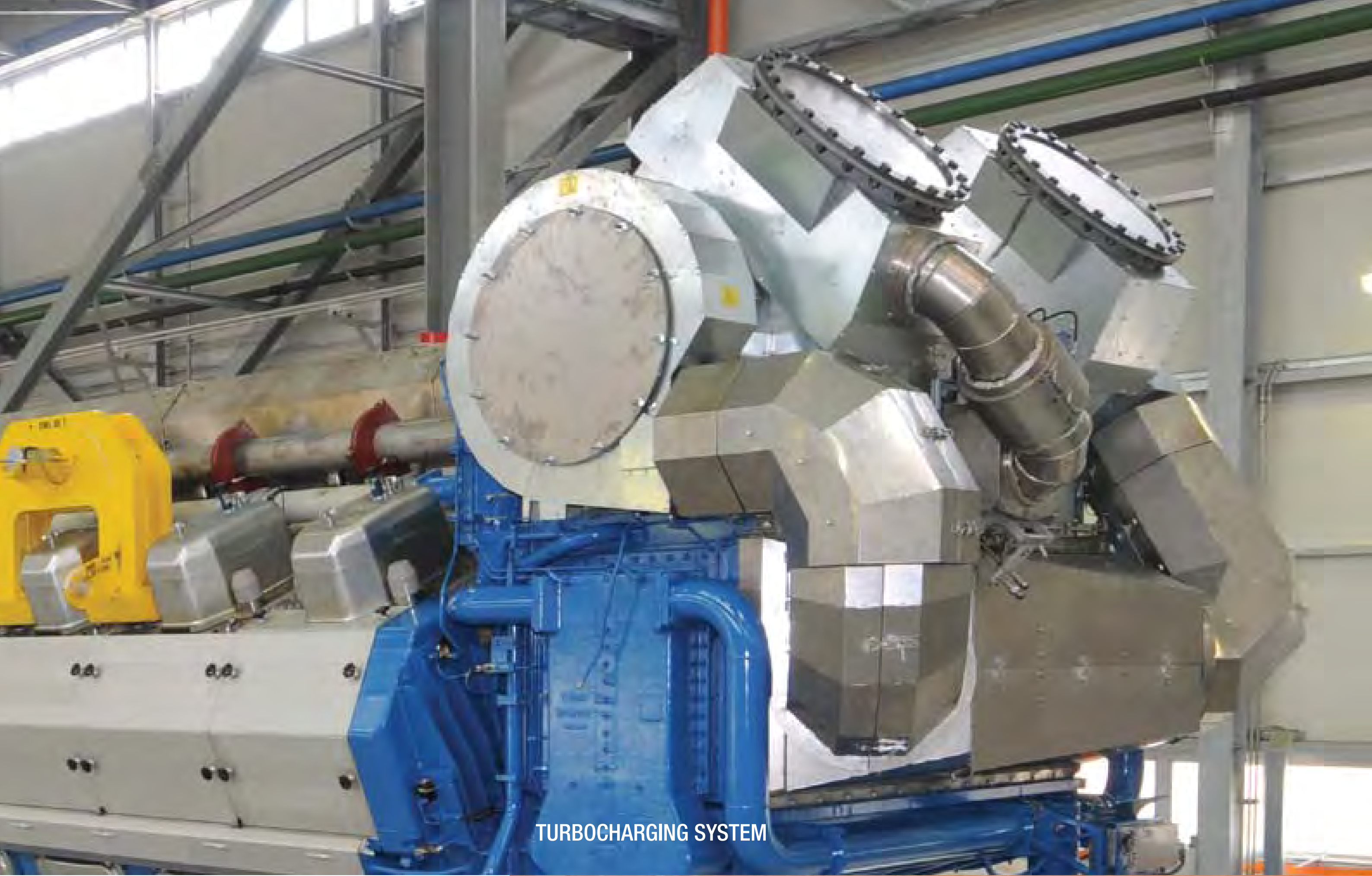
CONNECTING ROD

ENGINE BLOCK

PISTON RINGS

ENGINE BLOCK

Nodular cast iron is the natural choice for engine blocks today due to its strength and stiffness properties. The Wärtsilä 50SG makes optimum use of modern foundry technology to integrate most oil and water channels. The result is a virtually pipe-free engine with a clean exterior. The engine has an underslung crankshaft, which imparts very high stiffness to the engine block, providing excellent conditions for main bearing performance. The engine block has large crankcase doors allowing easy maintenance.



TURBOCHARGING SYSTEM

CRANKSHAFT AND BEARINGS

The latest advance in combustion development requires a crank gear that can operate reliably at high cylinder pressures. The crankshaft must be robust and the specific bearing loads maintained at acceptable levels. Careful optimisation of crankthrow dimensions and fillets achieve this.

The specific bearing loads are conservative, and the cylinder spacing, which is important for the overall length of the engine, is minimised. In addition to low bearing loads, the other crucial factor for safe bearing operation is oil film thickness. Ample oil film thickness in the main bearings is ensured by optimal balancing of rotational masses and, in the big-end bearing, by ungrooved bearing surfaces in the critical areas.

CRANKSHAFT

TURBOCHARGING SYSTEM

Every Wärtsilä 50SG is equipped with a single pipe exhaust turbocharging system. The system is designed for minimum flow losses on both the exhaust and air sides. The interface between the engine and turbocharger is streamlined to avoid all the adaptation pieces and piping frequently used in the past. The Wärtsilä 50SG engine uses high-efficiency turbochargers with inboard plain bearings, and the engine lubricating oil is also used for the turbocharger.

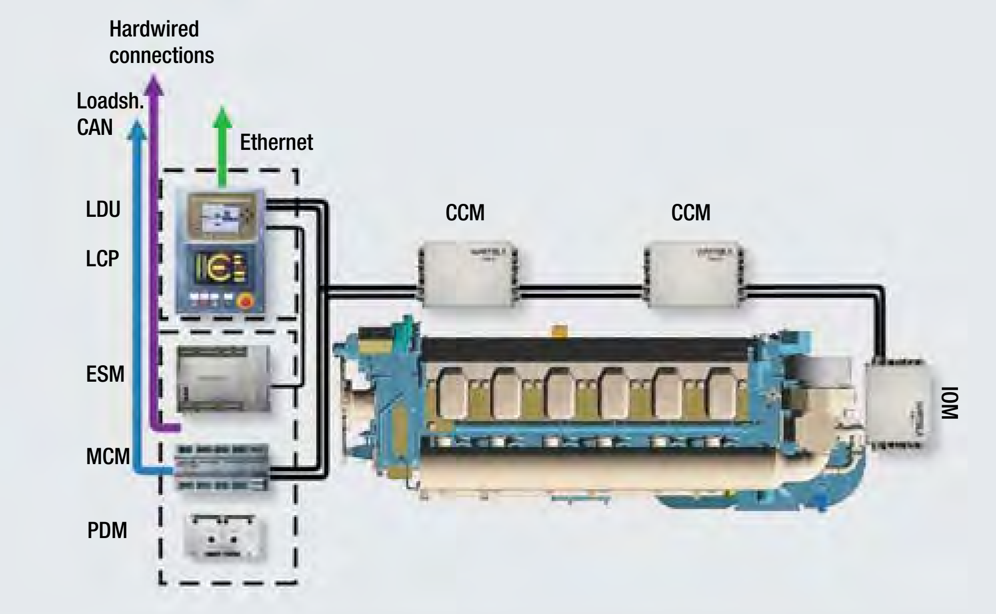
AUTOMATION

All engine functions are controlled by the UNIC (unified control) engine control system, a microprocessor-based distributed control system mounted on the engine. The various electronic modules are dedicated and optimised for certain functions and they communicate with each other via a CAN databus.

The engine control system offers the following advantages:

- Easy maintenance and high reliability due to point-to-point cabling, high quality cables and rugged mounting of engine electronics

POWER PLANT CONTROL ROOM



ENGINE CONTROL SYSTEM – UNIC C3

- Easy interfacing with external systems via a databus
- Reduced cabling on and around the engine
- High flexibility and easy customising
- Digitised signals – free from electromagnetic disturbance

MAIN CONTROL MODULE

The core of the engine control system is the main control module. This is responsible for ensuring the engine's reliable operation and for keeping the engine at optimum performance in all operating conditions such as varying ambient temperature and gas quality. The main control module reads the information sent by all the other modules. Using this information it adjusts the engine's speed and load control by determining reference values for the main gas admission, air-fuel ratio and ignition timing. The main control module automatically controls the start and stop sequences of the engine and the safety system. The module also communicates with the plant control system.

CYLINDER CONTROL MODULE

Each cylinder control module monitors and controls three cylinders. The cylinder control module controls the cylinder-specific air-fuel ratio by adjusting the gas admission individually for each cylinder.

The cylinder control module measures the knock intensity, i.e. uncontrolled combustion in the cylinder, which is used to control the cylinder-specific ignition timing and gas admission.

MONITORING MODULES

Monitoring modules are located close to groups of sensors, which reduces cabling on the engine. The monitored signals are transmitted to the main control module and used for the engine control and safety system. The monitored values are also transferred to the operator interface on the external control system.


Wärtsilä Condition Based Maintenance Support Centre.

EASY MAINTENANCE

The service life of the Wärtsilä 50SG engine components and the time between overhauls are very long with maintenance duration reduced to a minimum. The design allows for efficient and easy maintenance, and components accessibility is optimised through minimised use of external pipes and an ergonomical design.

For ease of maintenance, the engine block has large openings to the crankcase and camshaft. Hydraulics are extensively used for many operations, e.g. on all bolts requiring high tension. Since the main bearing caps are relatively heavy, each bearing cap is equipped with a permanently fitted hydraulic jack for easy manoeuvring of the cap. During delivery test runs, a running-in filter is installed to prevent the bearings from being scratched by any particles left in the oil system.

- Engine parts arrangement allows the cylinder head to be lifted without having to remove gas pipes or water pipes. The slide-in connections allow lifting of the cylinder head without the need to remove oil or air pipes.
- The water pumps are easy to replace thanks to the cassette design principle and water channel arrangement in the pump cover at the free end of the engine.
- A rigid and tight removable insulating box surrounds the exhaust system.
- Easy access to the piping system is obtained by removing the insulating panels.
- The camshaft is built of identical cylinder segments bolted to intermediate bearing pieces.
- Access to and maintenance of the spark plug and prechamber gas valve in the prechamber is easy. The prechamber does not need to be removed. For spark plug replacement, the valve cover does not need to be removed.
- Use of electrically controlled gas admission valves means few mechanical parts and less need for periodic adjustments.
- The three-piece connecting rod allows inspection of the big-end bearing without removal of the piston, and piston overhaul without dismantling the big-end bearing.

WÄRTSILÄ Engines

WÄRTSILÄ 50SG MAIN TECHNICAL DATA

Power production

Cylinder bore	500 mm
Piston stroke	580 mm
Speed	500/514 rpm
Mean effective pressure	22.0 bar
Piston speed	9.7/9.9 m/s
Natural gas specification for nominal load	
Lower heating value	28.0 MJ/m^3_N

Technical data 50 Hz/500 rpm	Unit	18V50SG
Power, electrical	kW	18 321
Heat rate	kJ/kWh	7411
Electrical efficiency	%	48.6
Technical data 60 Hz/514 rpm		
Power, electrical	kW	18 759
Heat rate	kJ/kWh	7411
Electrical efficiency	%	48.6
Dimensions and dry weight of generating set		
Length	mm	18 800
Width	mm	5330
Height	mm	6340
Weight	tonne	360

Heat rate and electrical efficiency at generator terminals, including engine driven pumps, ISO 3046 conditions and gas LHV > 28 MJ/Nm^3. Tolerance 5%. Power factor 0.8. Gas Methane Number > 80. Nm^3 defined at NTP (273.15 K and 101.3 kPa).

Wärtsilä is a global leader in complete lifecycle power solutions for the marine and energy markets. By emphasising technological innovation and total efficiency, Wärtsilä maximises the environmental and economic performance of the vessels and power plants of its customers. Wärtsilä is listed on the NASDAQ OMX Helsinki, Finland.

DBAB540961 / 03.2012 / Bock's Office /