

Comparative Analysis of Gas Turbine Compressor Efficiency Before and After DuraVee-to-DuraGT Final Filter Replacement at PT. Energi Listrik Batam

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Abstract: Compressor performance is one of the primary factors influencing the thermal efficiency and power output of a gas turbine. The condition of the inlet air filtration system plays a crucial role in compressor performance, as it directly affects airflow resistance and inlet air conditions. This study aims to analyze and compare the compressor efficiency of Gas Turbine Unit 1 at PT Energi Listrik Batam before and after the replacement of the final filter from the DuraVee® XL98 type to the DuraGT™ V300F9 type. The operational data used in this study consist of historical unit data collected from several representative operating periods, including the period when the DuraVee® XL98 final filter was in service, the initial operating period of the DuraGT™ V300F9 filter, and the most recent operating condition after five years of using the new filter type. The analyzed parameters include compressor inlet air pressure and temperature, pressure ratio, gas turbine power output, and compressor efficiency. The analysis was conducted by comparing compressor efficiency values under each operating condition based on selected and processed actual plant operating data. The results indicate that replacing the final filter type from DuraVee® XL98 to DuraGT™ V300F9 improved gas turbine compressor efficiency by 0.53–1.10%, with an average increase of 0.75% across all load conditions.

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INTRODUCTION

The demand for electricity consumption in Indonesia continues to increase each year in line with economic growth. Gas Turbine Power Plants (PLTG) are among the most widely used types of power plants in various regions due to their relatively high efficiency and flexibility in rapidly adjusting electrical loads according to system requirements. A gas turbine power plant operates by converting the chemical energy of fuel into mechanical energy through a gas turbine, which subsequently drives a generator to produce electricity (Hou et al., 2024; Naghibi, 2024). The reliability and performance of a gas turbine power plant depend on several key components, including the compressor, combustion chamber, gas turbine, and generator. To maintain operational efficiency and ensure continuous power production, proper maintenance of these components and the selection of appropriate supporting materials are critical aspects that must be comprehensively addressed (Aslan, 2024; Suchocki et al., 2023).

One type of gas turbine commonly used in gas turbine power plants is the PG6581B gas turbine, which is recognized for its high reliability, strong operational capability, low emissions, and excellent flexibility in adapting to grid demand (Kurz et al., 2024; Purba & Yuwana, 2024; Simanjuntak et al., 2024). This type of gas turbine is utilized by PT Energi Listrik Batam, an Independent Power Producer (IPP) with an installed gas turbine generation capacity of 2×35 MW. In the operation of the PLTG at

PT Energi Listrik Batam, the Frame 6B gas turbine compressor plays a crucial role by supplying high-pressure air required for the combustion process (Putra & Setiyono, 2024; Schuldt et al., 2020; Water & Plant, 2019; Yit et al., 2020). The compressor's efficiency directly affects the overall performance of the gas turbine system and, consequently, the efficiency of the entire power plant. Any modification to compressor components and their supporting systems, such as air filters, must therefore be technically evaluated to ensure performance improvements and efficient operation (Abid & Sarowar, 2022; Hassan & Manji, 2023).

Previous studies have indicated that the compressor air inlet filter is a vital component of the gas turbine air supply system because it functions to remove particles and contaminants from ambient air before it enters the compressor. Moreover, it has been reported to improve compressor efficiency by approximately 2–3% under baseload operating conditions (Brooks, 2000; Elwardany et al., 2023; Kowalczyk, 2022; Sunkler & Stalder, 2023). The selection of an appropriate filter is essential for maintaining the cleanliness of intake air, thereby minimizing component damage and efficiency losses caused by contamination. Ineffective filters may lead to reduced inlet air pressure, deteriorated compressor performance, and increased fuel consumption (Auda & Ali, 2023; Frank et al., 2015; Kotowicz et al., 2016; Mulyono, 2022). Therefore, any change in filter type must consider both filtration quality and its impact on the operational efficiency of the gas turbine compressor.

This study focuses on a comparative analysis of the efficiency of the gas turbine compressor in Unit 1 of PT Energi Listrik Batam before and after the replacement of the DuraVee final filter with the DuraGT filter. This focus was chosen to provide a clear understanding of the extent to which the replacement of the final filter type contributes to compressor efficiency improvement and to serve as a technical reference for future maintenance decisions and operational enhancement initiatives.

Based on the background presented above, this study addresses two main research questions: how to determine the compressor efficiency of the gas turbine when operating with DuraVee and DuraGT final filters, and how the compressor efficiency compares before and after the replacement of the DuraVee final filter with the DuraGT filter. Accordingly, the objectives of this research are to calculate the compressor efficiency values of the gas turbine under both DuraVee and DuraGT filter operating conditions and to analyze the differences in compressor efficiency resulting from the replacement of the DuraVee final filter with the DuraGT filter.

RESEARCH METHOD

This study is classified as a quantitative comparative study, which is a type of research that compares two or more variables numerically to identify differences or causal relationships among them. The primary focus of this study is to examine the differences in the performance of the gas turbine compressor of Unit 1 at PT Energi Listrik Batam before and after the replacement of the final filter from the DuraVee® XL98 type to the DuraGT™ V300F9 type. The analysis was conducted using operational data obtained from different years, namely 2019 when Unit 1 was still operating with the DuraVee® XL98 final filter, 2020 when Unit 1 first implemented the DuraGT™ V300F9 final filter, and the most recent operational data from 2025, during which Unit 1 continued to use the DuraGT™ V300F9 final filter. Through this study, it is expected that changes in compressor operating characteristics can be identified based on actual operational data without making any modifications to the existing system. Data processing was performed based on the thermodynamic principles of the

Brayton cycle to obtain a more measurable understanding of how the replacement of the final filter type affects the overall compressor performance.

This study utilized both primary and secondary data. Primary data were obtained from the Human Machine Interface (HMI) records in the Central Control Room (CCR) and from the Historical Trend Recorder of the GE PG6581B gas turbine Unit 1 at PT Energi Listrik Batam. Secondary data were obtained from manufacturer technical documents, including the DuraVee® XL and DuraGT™ V300/V450 Performance Specification Data, the GE PG6581B gas turbine operation manual, and air filtration standards such as ASHRAE 52.2:2007, EN779:2012, and ISO 16890-1:2016.

The data used in this study to analyze the comparative efficiency of the gas turbine compressor of Unit 1 at PT Energi Listrik Batam consisted of operational data collected when the unit was equipped with the DuraVee® XL98 final filter and after the installation of the DuraGT™ V300F9 final filter. All data were collected at nearly identical inlet air temperatures (T_1) when each final filter was newly installed in the air inlet housing. This approach was intended to ensure that the filtration system was operating under clean-condition circumstances and to minimize the influence of ambient temperature on compressor performance. The analyzed data covered a one-week operating period for each filter type under load conditions of 18 MW, 20 MW, 21 MW, and 25 MW.

The operational data presented in this section include the main parameters related to the performance of the gas turbine compressor of Unit 1 at PT Energi Listrik Batam while operating with the DuraVee® XL98 final filter. The data were collected over a one-week period from December 18 to December 25, 2019. All data were obtained from the power plant operational records through the HMI system and were subsequently screened and processed to ensure consistency and suitability for analysis. These data were used to evaluate the performance of the gas turbine compressor under the operating condition of the DuraVee® XL98 final filter.

Table 1. Operational Data of Unit 1 with the DuraVee® XL98 Final Filter

Parameter	18 MW	20 MW	21 MW	25 MW	Unit
Air Inlet Temperature (T_1)	29	29	29	29	°C
Compressor Discharge Pressure (P_2)	9.4	9.4	9.5	9.7	bar
Compressor Discharge Temperature (T_2)	343	344	346	351	°C
Exhaust Temperature (T_4)	382	390	398	432	°C
Fuel Gas Flow Rate ($\dot{m}_f$)	1.62	1.65	1.69	1.94	kg/s
Lower Heating Value (LHV)	48,875	48,875	48,875	48,875	kJ/kg

Operational Data of Unit 1 with the DuraGT Final Filter

The operational data presented in this section include the main parameters related to the performance of the gas turbine compressor of Unit 1 at PT Energi Listrik Batam after the replacement of the final filter with the DuraGT™ V300F9 type. The data were collected over a one-week period from December 20 to December 27, 2020. All data were obtained from the power plant operational records through the HMI system and were subsequently screened and processed to ensure consistency and suitability for analysis. These data were used to evaluate the performance of the gas turbine compressor while operating with the DuraGT™ V300F9 final filter.

Table 2. Operational Data of Unit 1 with the DuraGT™ V300F9 Final Filter

Parameter	18 MW	20 MW	21 MW	25 MW	Unit
Air Inlet Temperature (T_1)	29	29	28	28	°C
Compressor Discharge Pressure (P_2)	9.3	9.5	9.6	9.7	bar
Compressor Discharge Temperature (T_2)	338	344	344	345	°C
Exhaust Temperature (T_4)	371	377	392	396	°C
Fuel Gas Flow Rate ($\dot{m}_f$)	1.50	1.56	1.64	1.79	kg/s
Lower Heating Value (LHV)	48,875	48,875	48,875	48,875	kJ/kg

Recent Operational Data of Unit 1 with the DuraGT Final Filter

The operational data presented in this section represent the most recent operating data of the gas turbine Unit 1 at PT Energi Listrik Batam, including the key parameters related to compressor performance. During the data collection period, Unit 1 was still operating with the DuraGT™ V300F9 final filter. Data collection was conducted over a one-week period from October 23 to October 30, 2025. All data were obtained from the power plant operational records through the HMI system and were subsequently screened and processed to ensure consistency and suitability for analysis. These data were used to evaluate the performance of the gas turbine compressor after five years of operation since the initial implementation of the DuraGT™ V300F9 final filter in 2020.

Table 3. Current Operating Data of Unit 1 with DuraGT™ V300F9 Final Filter

Parameter	18 MW	20 MW	21 MW	25 MW	Unit
Air Inlet Temperature (T_1)	31	29	28	34	°C
Compressor Discharge Pressure (P_2)	9.2	9.4	9.5	9.6	bar
Compressor Discharge Temperature (T_2)	344	344	345	357	°C
Exhaust Temperature (T_4)	374	388	399	448	°C
Gas Flow ($\dot{m}_f$)	1.58	1.72	1.73	1.98	kg/s
LHV	48875				kJ/kg

Data Calculation

Data Calculation Using the DuraVee Final Filter

In this section, calculations were performed to determine the compressor efficiency and compressor work of Gas Turbine Unit 1 at PT Energi Listrik Batam using the DuraVee® XL98 final filter based on historical operating data from December 18–25, 2019. The compressor efficiency and work calculations were conducted using applicable thermodynamic equations in accordance with the calculation standards recommended in the gas turbine operation manual. The following is a sample calculation of compressor efficiency and compressor work at an 18 MW load.

18 MW Load

The compressor inlet enthalpy (h_1), compressor discharge enthalpy (h_2), theoretical compressor discharge enthalpy (h_2'), compressor efficiency (η_{ca}), combustion outlet enthalpy (h_3), combustion outlet temperature (T_3), heat supplied to the combustion chamber (Q_{in}), air mass flow rate ($\dot{m}_a$), and compressor work (W_{ca}) were calculated using the corresponding thermodynamic relationships and interpolation methods. Based on these calculations, the compressor efficiency was found to be

83.74%, while the compressor work was 48,638.3 kJ/s. Using the same calculation procedure for loads of 20 MW, 21 MW, and 25 MW, the results presented in Table 4 were obtained.

Table 4. Calculation Results Using the DuraVee® XL98 Final Filter

Load (MW)	η_{ca} (%)	Wca (kJ/s)	Qin (kJ/s)	$\dot{m}_a$ (kg/s)
18	83.74	48,638.3	79,178	126.63
20	83.47	48,734.3	80,644	126.05
21	83.46	48,928.3	82,599	125.72
25	83.16	51,790.6	94,818	130.48

Data Calculation Using the DuraGT Final Filter

Using the same calculation method, compressor efficiency and compressor work were determined for Gas Turbine Unit 1 at PT Energi Listrik Batam under loads of 18 MW, 20 MW, 21 MW, and 25 MW with the DuraGT™ V300F9 final filter. The results are presented in Table 5.

Table 5. Calculation Results Using the DuraGT™ V300F9 Final Filter

Load (MW)	η_{ca} (%)	Wca (kJ/s)	Qin (kJ/s)	$\dot{m}_a$ (kg/s)
18	84.59	45,292.6	73,313	121.09
20	84.01	47,397.9	76,245	123.38
21	83.99	47,442.5	80,155	123.10
25	84.25	50,976.9	87,486	132.24

Current Data Calculation Using the DuraGT Final Filter

Using the same methodology, compressor efficiency and compressor work were also calculated using the most recent operating data of Gas Turbine Unit 1 at PT Energi Listrik Batam for loads of 18 MW, 20 MW, 21 MW, and 25 MW with the DuraGT™ V300F9 final filter. The results are shown in Table 6.

Table 6. Current Calculation Results Using the DuraGT™ V300F9 Final Filter

Load (MW)	η_{ca} (%)	Wca (kJ/s)	Qin (kJ/s)	$\dot{m}_a$ (kg/s)
18	83.44	49,378.7	77,223	128.47
20	83.47	51,121.8	84,065	132.22
21	83.19	50,005.6	84,554	128.09
25	83.67	51,237.3	96,773	129.36

Data Analysis and Presentation

Data Analysis

The performance analysis of the compressor in Gas Turbine Unit 1 at PT Energi Listrik Batam was conducted using a comparative analysis between different operating periods. Compressor efficiency and compressor work values during the DuraVee® XL98 operating period (2019) were compared with those during the initial implementation of the DuraGT™ V300F9 filter (2020) and the current operating condition in 2025. Differences in performance were analyzed from a technical perspective by relating changes in parameter values to the characteristics of the final filter and the operating conditions of the unit. The analysis focused on identifying compressor performance changes

resulting from the replacement of the final filter type while maintaining consistency in the calculation method based on the Standard Operating Procedure and the GE Gas Turbine Manual Book.

Data Presentation

The results of the analysis are presented in the form of comparative line graphs illustrating the differences in compressor efficiency and compressor work across the different final filter operating periods. The purpose of these graphs is to facilitate observation of performance improvements or declines resulting from the replacement of the final filter, allowing changes in compressor performance to be clearly identified. Each graph is accompanied by a technical discussion explaining the significance of the observed differences and their relationship to operating parameters affecting compressor performance. These explanations are linked to the objectives of the study and the operating conditions of Gas Turbine Unit 1 at PT Energi Listrik Batam, ensuring that the presented data not only display calculation results but also provide a comprehensive technical understanding of changes in compressor performance.

RESULTS AND DISCUSSION

Comparison of Compressor Efficiency Using DuraVee (2019) and DuraGT (2020) Final Filters

The calculated compressor efficiency of Gas Turbine Unit 1 at PT Energi Listrik Batam when using the DuraVee® XL98 final filter (2019) and the DuraGT™ V300F9 final filter (2020) was analyzed through comparative graphs to identify changes in compressor efficiency resulting from the replacement of the final filter type. The comparison graph of compressor efficiency values is presented in Figure 1.

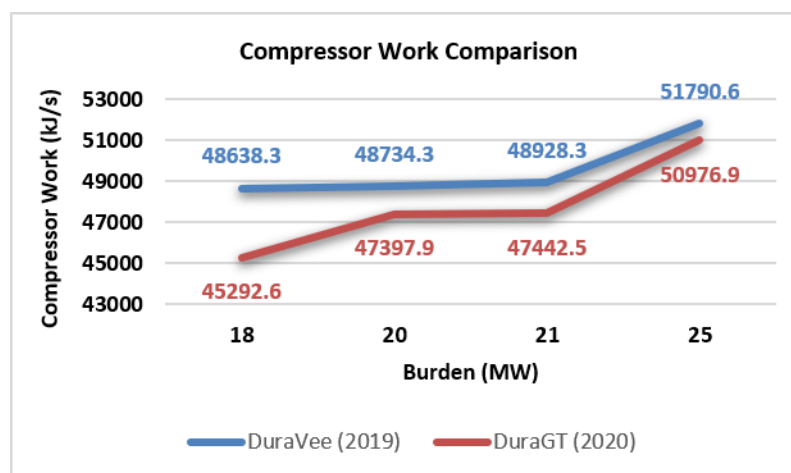


Figure 1. Comparison of Compressor Efficiency (η_{ca}) Using DuraVee and DuraGT Final Filters

Based on the efficiency comparison graph across different load variations, it can be observed that the compressor efficiency achieved with the DuraGT™ V300F9 final filter (2020) is consistently higher than that obtained with the DuraVee® XL98 final filter (2019) at all analyzed load levels. The quantitative increase in compressor efficiency is presented in Table 7.

Table 7. Changes in Compressor Efficiency Between 2019 and 2020

Load (MW)	DuraVee 2019 (%)	DuraGT 2020 (%)	Efficiency Difference (%)
18	83.74	84.59	+0.85
20	83.47	84.01	+0.54
21	83.46	83.99	+0.53
25	83.16	84.25	+1.09
Average Efficiency Improvement			+0.75

The observed efficiency improvement ranges from 0.53% to 1.09%, with an average increase of 0.75%. Although numerically modest, this improvement is technically significant for the GE Frame 6B gas turbine, considering that more than 50% of the turbine output power is utilized to drive the compressor. The highest compressor efficiency of 84.59% was recorded at an 18 MW load with the DuraGT™ V300F9 final filter (2020), while the lowest efficiency of 83.16% occurred at a 25 MW load with the DuraVee® XL98 final filter (2019).

The higher compressor efficiency achieved with the DuraGT™ V300F9 final filter indicates that the lower initial resistance or initial pressure drop of this filter contributes positively to compressor performance. A high-efficiency filtration system effectively reduces the number of fine particles entering the compressor, thereby maintaining cleaner compressor blade surfaces and minimizing frictional losses as well as flow separation. Superior filter performance helps stabilize airflow, reduce inlet air contamination, and preserve the aerodynamic characteristics of the compressor blades.

Comparison of Compressor Efficiency Using DuraGT Final Filters in 2020 and 2025

This section presents a comparative analysis of the compressor efficiency of Gas Turbine Unit 1 at PT Energi Listrik Batam during operation with the DuraGT™ V300F9 final filter in 2020 and under current operating conditions in 2025, while maintaining the same final filter configuration. The comparison aims to evaluate the extent to which compressor performance has changed over a five-year operating period and to identify potential efficiency degradation that may occur despite the use of an identical air filtration system. By examining compressor efficiency under comparable operating loads, this analysis provides insight into the long-term operational behavior of the compressor and the influence of factors such as component aging, fouling, wear of internal parts, and changes in overall turbine operating conditions. Furthermore, the comparison serves to determine whether the efficiency improvements achieved following the implementation of the DuraGT™ V300F9 filter in 2020 have been sustained over time. The results of this evaluation are expected to provide valuable information regarding the condition of the compressor system, support maintenance planning, and contribute to strategies aimed at preserving the reliability, performance, and thermal efficiency of the gas turbine throughout its operational life.

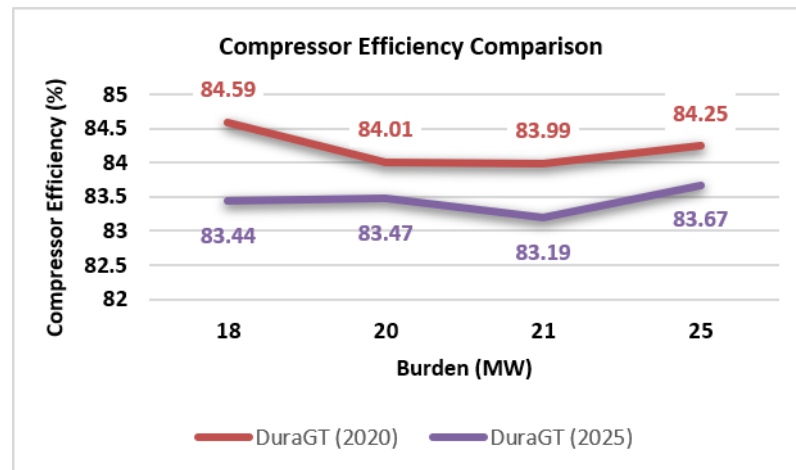


Figure 2. Comparison of Compressor Efficiency (η_{ca}) Using DuraGT Final Filters in 2020 and 2025

Based on the compressor efficiency comparison graph shown in Figure 2, the compressor efficiency in 2025 is consistently lower than that recorded in 2020 across all analyzed load variations. The quantitative reduction in compressor efficiency is summarized in Table 8.

Table 8. Changes in Compressor Efficiency Between 2020 and 2025

Load (MW)	DuraGT 2020 (%)	DuraGT 2025 (%)	Efficiency Difference (%)
18	84.59	83.44	-1.15
20	84.01	83.47	-0.54
21	83.99	83.19	-0.80
25	84.25	83.67	-0.58
Average Efficiency Reduction			-0.77

The reduction in compressor efficiency ranges from 0.54% to 1.15%, with an average decrease of 0.77%. A consistent decline in compressor efficiency directly affects effective airflow, pressure ratio, compressor work, and overall heat rate. Consequently, the results indicate that the reduction in compressor efficiency observed in 2025 reflects performance degradation that is closely associated with the condition of the air filtration system and the internal condition of the compressor. This degradation may result from long-term operational effects such as blade fouling, component wear, and the gradual deterioration of filtration effectiveness, all of which negatively impact the aerodynamic performance of the compressor and the overall efficiency of the gas turbine system.

Graphical and Tabular Comparison of Compressor Performance

Comparison between DuraVee Final Filter (2019) and DuraGT Final Filter (2020)

This subsection presents an analysis of the compressor performance of Gas Turbine Unit 1 at PT Energi Listrik Batam based on the relationship between operating load and compressor work under two different final filter configurations: the DuraVee® XL98 filter (2019) and the DuraGT™ V300F9 filter (2020). The comparison aims to evaluate changes in compression work requirements resulting from differences in air filtration system characteristics.

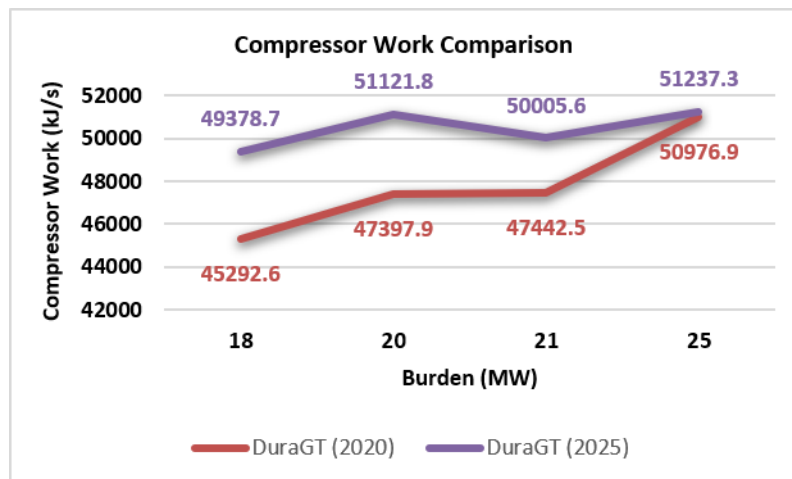


Figure 3. Comparison of Compressor Work (Wca) Using DuraVee and DuraGT Final Filters

Based on the compressor work comparison graph, it can be observed that across all operating loads analyzed, the compressor work associated with the DuraGT™ V300F9 final filter (2020) is consistently lower than that of the DuraVee® XL98 final filter (2019). The quantitative reduction in compressor work is presented in Table 9.

Table 9. Changes in Compressor Work between 2019 and 2020

Load (MW)	DuraVee 2019 (kJ/s)	DuraGT 2020 (kJ/s)	Difference (kJ/s)	Reduction (%)
18	48,638.3	45,292.6	-3,345.7	6.88
20	48,734.3	47,397.9	-1,336.4	2.74
21	48,928.3	47,442.5	-1,485.8	3.04
25	51,790.6	50,976.9	-813.7	1.57
Average Compressor Work Reduction	-	-	-1,745.4	3.56

At an operating load of 18 MW, compressor work decreased from 48,638.3 kJ/s to 45,292.6 kJ/s, representing a reduction of 3,345.7 kJ/s (6.88%), which is the largest decrease among all operating points. This reduction indicates a significant decrease in inlet system pressure drop, resulting in lower energy requirements for the compression process. At medium loads of 20–21 MW, a similar trend is observed, with compressor work reductions of 1,336.4 kJ/s (2.74%) and 1,485.8 kJ/s (3.04%), respectively. Although the percentage reductions are smaller than those observed at 18 MW, the absolute reductions remain thermodynamically significant because compressor work constitutes the largest internal power consumption component in a Frame 6B gas turbine. The reduction in energy demand suggests that the filtration characteristics of the DuraGT filter are capable of maintaining intake air quality while sustaining a lower pressure drop during operation. At the higher load of 25 MW, compressor work remained lower by 813.7 kJ/s (1.57%). Overall, the average reduction in compressor work across the entire operating range was 1,745.4 kJ/s (3.56%). This reduction directly contributes to improved compressor efficiency, lower specific fuel consumption, and reduced mechanical loading on the compressor system. Therefore, the implementation of the DuraGT™

V300F9 final filter provides both thermal benefits and a measurable improvement in system reliability compared with the DuraVee® XL98 filter.

Comparison between DuraGT Final Filter (2020) and DuraGT Final Filter (2025)

This section presents a comparison of the compressor performance of Gas Turbine Unit 1 at PT Energi Listrik Batam during operation with the DuraGT™ V300F9 final filter in 2020 and under current operating conditions in 2025. The objective is to evaluate changes in compression work requirements over time, despite the use of the same final filter type.

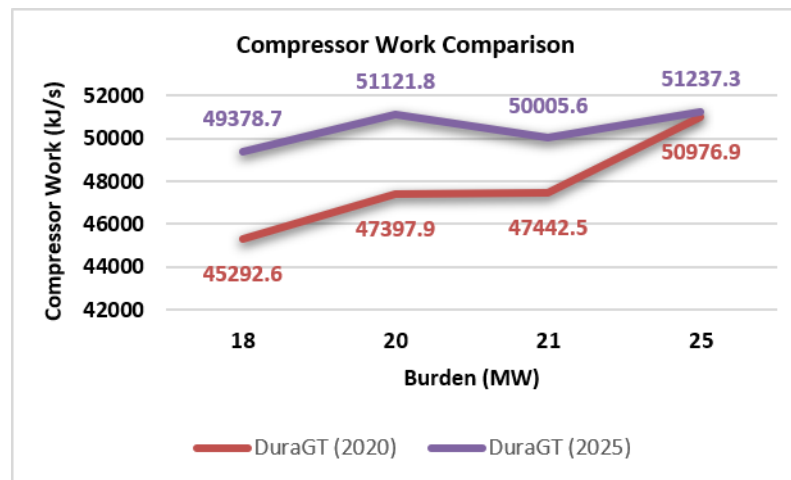


Figure 4. Comparison of Compressor Work (Wca) Using DuraGT Final Filter in 2020 and 2025

The compressor work comparison graph shows a consistent increase in compressor work in 2025 relative to the 2020 operating condition across the entire load range of 18–25 MW. At 18 MW, compressor work increased from 45,292.6 kJ/s to 49,378.7 kJ/s, representing an increase of 4,086.1 kJ/s (9.02%). This is the largest deviation observed and indicates the presence of additional flow resistance or a significant reduction in aerodynamic efficiency under partial-load conditions. At 20 MW, compressor work increased by 3,723.9 kJ/s (7.86%), from 47,397.9 kJ/s to 51,121.8 kJ/s, indicating that a larger portion of turbine power is being consumed to drive the compressor, thereby reducing the net power output of the unit. This upward trend continued at 21 MW, where compressor work increased by 2,563.1 kJ/s (5.40%), suggesting that performance degradation occurred systematically and was not limited to a specific operating point. At the higher load of 25 MW, the increase was relatively smaller at 260.4 kJ/s (0.51%), yet it still indicates additional system losses, although proportionally masked by the dominant effects of pressure ratio and air mass flow rate at higher loads. The quantitative increase in compressor work is presented in Table 10.

Table 10. Changes in Compressor Work between 2020 and 2025

Load (MW)	DuraGT 2020 (kJ/s)	DuraGT 2025 (kJ/s)	Difference (kJ/s)	Improvement (%)
18	45,292.6	49,378.7	+4,086.1	9.02
20	47,397.9	51,121.8	+3,723.9	7.86
21	47,442.5	50,005.6	+2,563.1	5.40
25	50,976.9	51,237.3	+260.4	0.51

Average Compressor Work Improvement	+2,658.4	5.69
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Overall, the average increase in compressor work was 2,658.4 kJ/s, equivalent to 5.69% compared with the 2020 operating condition. Since 1 kJ/s is equivalent to 1 kW, this increase corresponds to an additional internal power consumption of 2,658.4 kW by the gas turbine compressor. Assuming that Gas Turbine Unit 1 at PT Energi Listrik Batam operates for 8,000 hours annually, this increase in compressor work results in an additional internal energy consumption of approximately 21,267.2 MWh per year. This condition indicates increasing losses within the gas turbine system and a shift in the energy distribution throughout the cycle, whereby a portion of turbine output that would otherwise contribute to net power generation is instead consumed to satisfy compression requirements. Although the unit continues to operate under stable conditions, this trend reflects a reduction in cycle efficiency margins and has the potential to increase heat rate as well as thermal loading on rotating components. Therefore, these results highlight the need for a comprehensive performance evaluation of the gas turbine system through continuous monitoring of key compressor operating parameters and the strengthening of condition-based maintenance strategies to sustain long-term unit reliability and efficiency.

CONCLUSION

Based on the calculation results, graphical analysis, and discussion regarding the comparison of compressor efficiency and compressor work of Gas Turbine Unit 1 at PT Energi Listrik Batam before and after the replacement of the final filter from DuraVee® XL98 to DuraGT™ V300F9, several key conclusions can be drawn as follows:

The replacement of the final filter from DuraVee® XL98 to DuraGT™ V300F9 was proven to consistently improve compressor efficiency across all load variations. Compressor efficiency with the DuraVee® XL98 filter (2019) ranged from 83.16% to 83.74%, whereas after the installation of the DuraGT™ V300F9 filter (2020), efficiency increased to a range of 83.99% to 84.59%. This represents an absolute efficiency improvement of 0.53–1.10%, with an average increase of 0.75%. From both theoretical and operational perspectives, this improvement is significant because, in a GE Frame 6B gas turbine, more than 50–60% of the turbine power is consumed by the compressor. Therefore, even a small increase in compressor efficiency can have a substantial impact on overall unit performance.

The use of the DuraGT™ V300F9 final filter reduced compressor work during the initial operating period (2020), indicating a reduction in aerodynamic losses and inlet airflow resistance. At a load of 18 MW, compressor work decreased from 48,638 kJ/s (DuraVee) to 45,293 kJ/s (DuraGT), representing a reduction of 3,345 kJ/s (6.88%). At a load of 25 MW, compressor work decreased from 51,791.6 kJ/s (DuraVee) to 50,977.9 kJ/s (DuraGT), corresponding to a reduction of 813.7 kJ/s (1.57%). This reduction indicates that the DuraGT™ final filter has a lower initial pressure drop, thereby reducing compressor workload and improving isentropic efficiency.

After five years of operation (2025), compressor efficiency declined by 0.54–1.15%, with an average decrease of 0.77%. However, compressor work increased significantly compared with the operating condition in 2020. The average increase in compressor work was 2,658.4 kJ/s (5.69%), with the highest increase of 4,086.1 kJ/s (9.02%) occurring at a load of 18 MW. These findings indicate that

although the filtration characteristics were still able to maintain efficiency within acceptable limits, system degradation factors such as gradual fouling and changes in airflow characteristics contributed to an increase in compression energy requirements.

The air filtration system plays a strategic role in maintaining the long-term performance of gas turbine compressors. The DuraGT™ V300F9 final filter, with its lower initial resistance and high filtration efficiency, is capable of minimizing blade fouling, maintaining stable air mass flow rates, and preserving compressor efficiency. The results of this study confirm that the quality of the final filter directly affects compressor efficiency, compressor work, and ultimately the thermal efficiency of the gas turbine unit.

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