POWER QUALITY INTERNATIONAL
2404 Merchant Avenue | Odessa, FL 33556

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CASE STUDY

Wynn Hotel & Casino

Macau, China

+ Company

Wynn Resorts Limited is a developer and operator of high-end hotels and casinos. The company's first project, Wynn Las Vegas, opened on April 28, 2005. The Encore, an extension to Wynn Las Vegas, broke ground on April 28, 2006 – the first anniversary of the opening of Wynn Las Vegas.

Wynn Macau, the company's first project in The Peoples Republic of China, started construction on June 28, 2004. It opened September 5, 2006. The Encore at Wynn Macau, the company's second tower, opened on April 21, 2010.

+ Challenge

On January 15, 2010, PQI received a report regarding a severe harmonic problem at the Wynn Macau Encore tower from JBA Consulting Engineers, who had been retained to evaluate performance issues on the hotel's electrical distribution systems. During the initial commissioning, JBA observed flickering lights in the guest rooms and unusual humming and vibration in the six distribution panels that supply the hotel's Diamond Feature. The Diamond Feature is a unique lighting display located on the exterior concave facade of the Encore tower. This display extends from the seventh floor to the fiftieth floor. The feature includes approximately 70,000 randomly controlled, dimmable cold cathode fluorescent lamps.

The average total harmonic distortion of current (THDI) at the lamps' local controllers was measured at 191%, while THDI at the six distribution panels was between 114% and 156%. High current distortion was thought to be the likely cause of panel humming and vibration. In an Ohm's law relationship with the distribution panel, which is most remote from the main switchgear, was 21%. These are the highest levels of current and voltage distortion ever presented to PQI. True Power Factor (TPF) on the riser supplying the Diamond Feature was measured at 0.68. Based on this information, we anticipated very high harmonic-current related "penalty losses" and very low efficiencies in the distribution system and its loads.

Under this load condition, THDV at the facility's main switchboard was measured at 19%. This level of baseline voltage distortion was therefore imposed on all other distribution system loads. Since a high percentage of these loads are also nonlinear, THDV is expected to be well above 10% at all other loads. IEEE Standard 519-1992 recommends a limit of 5% THDV at a system's loads. High voltage distortion was thought to be the likely cause of flickering lights in the guest rooms. In addition to diminishing system and load functionality and reliability, the presence of voltage distortion at the linear loads will result in identical current distortion; that is, %THDI will equal %THDV. In this environment, linear loads produce harmonic currents.

+ Solution

To resolve the observed operational issues, reduce distortion and "penalty losses" and improve power factor, PQI prepared a harmonic mitigation plan with guaranteed outcomes. This plan was presented to JBA Consulting Engineers on January 20, 2010 – five days after receiving their report. JBA sent our mitigation plan to the owner's representative for approval. To resolve all identified issues, our plan proposed the application of five ultra-efficient harmonic mitigating transformers at the line side of the five distribution panels that supply the Diamond Feature. These Distribution TransFilters™ (filters) were to be used to convert the Diamond Feature's six-pulse loads to a twenty-four-pulse load at their common 400-volt riser. The filters would also create a separately derived grounded neutral adjacent to each distribution panel and reduce the distribution system's zero-sequence impedance by approximately 200X. We discovered later that PQI's proposed solution was one of three presented to the owner's representative.

The Wynn organization elected to proceed with a solution prepared by Schneider Electric (Square D). Their solution required the application of an active harmonic filter (AHF) at each of the Diamond Feature's five distribution panels. These devices are designed to analyze a circuit's harmonic current profile then inject harmonic currents, which are equal in magnitude but 180° out-of-phase, into the circuit. This effectively cancels the load-generated harmonic currents. Unfortunately, the Diamond Feature's lamp controllers produce a current rise time and duration that was well beyond the AHF's ability to track or mitigate. This problem actually caused the AHF to increase current and voltage distortion. To increase the currents' rise time and duration and reduce harmonic current magnitudes, Schneider next applied a one-to-one, K-Rated distribution transformer at the line end of the riser. This caused a further increase in voltage distortion. The result was an unacceptable failure rate of the dimmable cold cathode fluorescent lamps, which cost $10.00 US each. As a result, the AHFs and K-Rated transformer were removed from service.

With these serious issues unresolved, the owner next engaged JBA to undertake harmonic modeling of the affected distribution system. Upon completion of their study, JBA produced a comprehensive report in January 2011, which described the performance of the existing system under nonlinear loading (baseline). Their calculations closely approximated the site measurements taken one year earlier. The report then described the performance of the system with the addition of Schneider Electric's active harmonic filters and K-Rated distribution transformer.

JBA's report then detailed anticipated outcomes based on solutions offered by General Electric and PQI. The report concluded that only PQI's proposed solution would reduce voltage distortion at the main switchboard to an acceptable level, the key requirement with respect to the flickering light problem, and reduce harmonic current loading at the five distribution panels. Based on this report, PQI was authorized to proceed.

+ Impact

Before installing the five Distribution TransFilters™, PQI took a full set of power and harmonic measurements at the main switchboard that supplies the Diamond Feature and the Encore tower's guest rooms most affected by voltage distortion, the five Diamond Feature lighting control panels and the five distribution panels that supply them. Upon completion, the proposed filters were installed, the lighting feature was reenergized and a new complete set of measurements were taken. Before and after measurements revealed the following outcomes at the main switchboard:

Before Mitigation	After Mitigation	Reduction
19% THDV	4.4% THDV	77%

This reduction met the IEEE Standard 519 recommendation and resolved the "flickering lights" problem.

The initial measurements revealed a significant but previously unreported problem, that is, high neutral-to-ground voltage at the five distribution panels and lighting controls. Before and after measurements revealed the following average outcome:

Before Mitigation	After Mitigation	Reduction
13.1V	2.5V	81%

This reduction met the Information Technology Industry Council (ITIC) recommendation and will likely reduce lighting controller and/or lamp failures.

With the conversion of the Diamond Feature lighting loads from six-pulse to twenty-four-pulse, current distortion and RMS current were reduced, while power factor was improved, on the 400-volt riser:

Before Mitigation	After Mitigation	Reduction
120% THD_I	72.6%	THD_I 39.5%
178A/Ø & 285A_N	127A/Ø & 0A_N	28.7%/Ø & 100%$_N$
0.680 PF	0.979 PF	

High neutral currents, which exceeded the phase currents, were totally eliminated on the riser. The efficiency improvement from the reduction in the distribution system's load losses has resulted in a very attractive financial benefit.

A more complete analysis of these operational and power quality issues, their resolution and the financial outcome are discussed in a paper authored by JBA Consulting Engineers and Power Quality International.

POWER QUALITY INTERNATIONAL is the industry leader in the development, design and manufacturing of harmonic mitigating and energy -efficient transformer technologies. With a passion for solving problems and helping customers achieve power quality and energy efficiency, PQI delivers cost-effective solutions that ensure power quality and energy efficiency for the life of their customers facilities.