CASE STUDY

University of Maryland
Walter P. Carter Behavioral Health Center

Facility Description

The Walter P. Carter Behavioral Health Center is located in a relatively small three-story building that was completed in 1983. This outpatient center consists mainly of small medical offices.

When compared to the facility's combined 277-volt lighting and 480-volt HVAC loads, its 120-volt office loads actually consume more energy. This load group's harmonic current-generating switch-mode power supplies create the facility's best energy-saving opportunity.

The Behavioral Health Center was selected as the university's 'pilot project' because the three distribution transformers that supply the office loads were individually metered. This allowed for Baltimore Gas & Electric, who partially funded the project, and the university to confirm PQI's projected power savings.

Existing Conditions

- Inefficient pre-NEMA TP 1 distribution transformers
- 17% average daytime loading of the transformers
- Unacceptable levels of positive-, negative- and zero-sequence harmonic currents
- Unacceptable zero-sequence harmonic impedances at 208/120-volts

The existing distribution transformers were installed before the imposition of US DOE transformer efficiency legislation. In 1983, single-phase nonlinear electronic office and lighting loads did not exist. K-Rated or harmonic mitigating low voltage distribution transformers had not yet been developed.

Pre-NEMA TP 1 distribution transformers have higher losses and lower efficiencies than DOE 2016 compliant units. At an average daytime loading of only 17%, the pre-NEMA TP 1 transformers' excitation losses were extremely high, resulting in unacceptably low energy efficiencies. Light distribution transformer loading is typical when complying with the requirements of the National Electrical Code.

Compared to all other nonlinear load types, single-phase switch-mode power supplies generate the highest levels of positive- and negative-sequence harmonic currents (≈ 3.5X higher than a three-phase power rectifier). When connected phase-to-neutral, single-phase switch-mode power supplies also generate extremely high levels of zero-sequence harmonic currents (i.e. $I_3 \approx 82\%$ of I_1).

In an Ohm's Law relationship with the existing transformers' high zero-sequence impedances, zero-sequence harmonic currents generate high levels of zero-sequence harmonic voltages ($E_0 = I_0 \times Z_0$) and voltage distortion. Distortion of the 60Hz sinusoidal waveform, which is always highest at the loads, will produce significant load 'penalty losses', reduce the switch-mode power supplies' efficiencies and reduce the 208/120-volt system's power factor.

Challenge

PQI challenge was to improve transformer efficiency, reduce the subsystems' zero-sequence impedances, improve load efficiencies, increase load power factors and reduce the 480-volt system's harmonic current-generated 'penalty losses', while ensure system-load compatibility.

Solution

PQI was contracted by the University of Maryland Medical Center to develop a distribution system solution that would reduce 'penalty losses', increase efficiency and power factor, improve overall power quality and ensure system-to-load compatibility.

After confirming each transformer's maximum and average load factors, and harmonic current load profile, PQI's engineers optimized the system by replacing the three oversized, inefficient transformers with rightsized, ultra-efficient harmonic mitigating transformers. The transformer downsizing was made in accordance with CSA C802.4, national**grid**® guidelines, and NEC requirements.

To maximize payback and return-on-investment we were limited in downsizing to one standard kVA rating. This limitation, which was far less than recommended by CSA or national**grid**® guidelines, was necessary to avoid the need to change existing transformer and circuit protection and conductors.

Impact

- **88,980 kWh** annual power savings
- **$9,516** annual utility savings
- **12%** reduction in annual energy cost
- **$304,512 l**ifetime net profit, based on 32-year life cycle
- **$5,018** Baltimore Gas & Electric rebate
- **22%** of project paid by BG&E
- **1.9 years** project payback