The façade of Pushpawati Singhania Research Institute

Optimizing Building Performance at Pushpawati Singhania Research Institute

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Introduction

Located in South Delhi, India, Pushpawati Singhania Research Institute (PSRI) is a multispecialty institute of national and international repute, known for its expertise in Nephrology, Urology and Gastroenterology. Officially opened in 1996, the facility was established with a focus on providing curative and preventive medical care through a caring environment. PSRI has built a reputation for itself as one of South East Asia's leading institutes providing highly specialized tertiary level treatment across multiple disciplines. The state-of-the-art facility is staffed by a team of highly experienced and specialized doctors who are leaders in their respective fields and cater to both international and domestic patients. To enable patients to recuperate in a restful and conducive environment, it is critical for the hospital to create an indoor environment that offers optimal humidity and temperature levels. This is important as providing a holistic and therapeutic environment that facilitates healing helps promote faster patient recovery.

One of the issues that PSRI faced was that its centralized air conditioning system was inefficient and incurring unnecessary costs in the form of excessive energy usage. Due to the high human traffic and footfall, the aging air conditioning system was unable to meet rising load conditions and was consuming 60 percent to 70 percent of the hospital's electricity bill. As such, it was clear that the facility was in need of a retrofit solution.

About the Author

Nanthagopalan T.K. is currently the Director of Service at Johnson Controls India for all lines of business (HVAC, IR and Controls). He started his career with Sabroe Refrigeration (later known as York International) in 1996 and joined Kirloskar McQuay for a stint before returning to York as head of its HVAC Service. He holds a Master of Engineering in Refrigeration and Air Conditioning and is a LEED Accredited Professional.

Energy Audit – Key Findings

In order to better understand the solution required, an energy audit was conducted by the team a month before the commencement of the project to study the energy usage patterns at the facility. In addition, the team analyzed the performance of the system and identified specific problems with the current equipment.

- The facility originally ran on six water-cooled chillers with a capacity of 50 tons of refrigeration (TR) each, providing an efficiency rate of 1.1kW/TR that was below expectations.
- The old cooling system had a power factor of 0.75, which fell short of the 0.99 power factor required by the facility.
- The issues were further compounded by the fact that the monobloc pumps in use were operating at less than 50 percent efficiency. Moreover, the undersized cooling towers were operating at 14 degrees Fahrenheit instead of the 7 degrees Fahrenheit they were designed for.

In sum, the inefficiency of the system combined with the underutilization of the cooling system resulted in an annual consumption of 1,049,272 units of electricity, derived from consolidated real annual data.

The Solution

Following the audit, it was found that the load of the facility was less than 400 TR at any point of time. The team replaced the existing energy guzzler reciprocating chillers with two units of highly efficiency York® water-cooled screw chillers, each with a capacity of 200 TR and an average energy consumption of 0.525 kW/TR. It was less than half of the original chillers, which had an average consumption of 1.345 kW/TR. The team also advised PSRI to keep two out of six of the original 50 TR chillers as backups.

Photo 1: York chiller at PSRI

Photo 2: Inline chilled water pumps

In addition, three 300 TR cooling towers, primary and secondary chiller pumps, condenser water pump and main electrical panel were installed.

The original monobloc pumping system was replaced with highly efficient inline pumps, each with Variable Frequency Drive (VFD) mounted on the pump itself, which utilized half the space previously taken by the monobloc pumps. The adjustments had a significant impact – improving the efficiency of the pumps by 35 percent at full load and by 50 percent at part load.

Photo 3: Inline condenser water pumps

The cooling towers were also redesigned according to the site architecture and heat to be rejected. The two new 300 TR cooling towers were able to operate at the optimal temperature of 7 degrees Fahrenheit – compared to 14 degrees Fahrenheit with the previous setup – which resulted in a further 15 percent energy saving from the chillers. To keep the cooling towers running at optimal conditions, the team also recommended the use of hydrochloric acid to maintain the pH level of water. Other measures to address scaling and corrosion control were also implemented.

Challenges

The key challenge faced by the team was to implement the entire retrofitting project without affecting the daily operations of the hospital. As this was an operational hospital, it was not possible to shut down or disrupt the system for even a single day.

To get around this, the project team chose to carry out the retrofits during winter when there was lesser requirement for the air conditioning system. For example, the chillers, pumps and cooling towers were installed and connected at night during winter to avoid any disruptions. This way, it was business as usual for the facility during the day.

Project Execution

During the retrofit project, the team was sensitive to the needs of the hospital and its patients and managed the installation works without disrupting the operations of the

Table 1: Chiller Performance Chart – York water-cooled screw chillers

Client		PSRI Hospital, New Delhi	
Chiller Details		York Chiller	
Refrigerant		R 134A	
Ambient Wet Bulb		21 °C	21.1 °C
Description	**Unit**	**Set- 1**	**Set-2**
Time		15:00	15:30
Evaporator			
Entering chilled water temperature	°C	54.9	50.8
Leaving chilled water temperature	°C	47.1	44.6
Evaporator approach	°C	2.9	2.5
Evaporator water flow	m^3/hr	128.35	119.30
Condenser			
Entering water temperature	°C	80.9	80.4
Leaving water temperature	°C	91.5	88.7
Condenser approach	°C	2	1.2
Compressor			
Compressor load	% FLA	80	65
Input power	kW	95	75
Output Parameter (Evaporator Side)			
Tonnage delivery	TR	**183.5**	**135.6**
Specific Energy Consumption	kW/TR	**0.52**	**0.55**
COP		6.79	6.35

Table 2: Chiller Performance– old water-cooled reciprocating chillers

Client		PSRI Hospital, New Delhi	
Chiller Details		Old Reciprocating Chiller-2	
Refrigerant		R 22	
Ambient		**21 °C**	**21 °C**
Description	**Unit**	**Set- 1**	**Set-2**
Time		16:00	16:30
Evaporator			
Entering chilled water temperature	°C	17.8	17.75
Leaving chilled water temperature	°C	16.5	16.4
Evaporator water flow	m^3/hr	66	66.2
Compressor			
Voltage	V	413	412
Current	A	75	76
Power factor		0.72	0.74
Input power	kW	38.9	39.2
Output Parameter (Evaporator Side)			
Tonnage delivery	TR	28.3	29.5
Specific Energy Consumption	kW/TR	1.37	1.32
COP		2.55	2.65

hospital. The project was completed within 45 days – 15 days ahead of schedule.

In addition, the hospital also recovered 450 square feet of space previously occupied by the six old chillers. The two new chillers have higher capacities, but take up less space due to the incorporation of vertical inline pumps. The freed space could be used to house more chillers for an extension of the hospital. This effectively allows the hospital to create a single plant room that is able to serve two different buildings, easing the operations and maintenance efforts.

Results and Measurements

Before embarking on this retrofit project, the team compared the efficacy of the initial and proposed new systems based on current demands. The total energy consumption of the previous system was 1,049,272 units of electricity while the estimated consumption of the proposed system was only 504,572 units of electricity – a reduction of more than 50 percent.

Upon completion of the project, PSRI recorded electrical savings of about INR five million in the first year, equivalent to US$70,000. The substantial savings also project a payback period of only 25 months.

A detailed performance evaluation of the chillers was also conducted. Specific Power Consumption (SPC, kW/TR) is the best indicator for the performance of a chiller. To arrive at the SPC, inlet and outlet temperatures of the chilled water and condenser water were measured, and so was flow rate. The measurements were taken at various point of time. Based on these measurements, actual delivered TR was calculated. The corresponding power consumption by the compressors was then measured to ascertain the present SPC in kW/TR. It was determined that the SPC of the new chillers was approximately 0.525 kW/TR on average, more than twice as efficient as the older chillers which had an average SPC of approximately 1.345 kW/TR.

Conclusion

In all, the redesigned air-conditioning system has a higher energy efficiency, allowing PSRI to reduce its expenditure on air conditioning while ensuring that the hospital could continue to provide quality and energy-efficient air conditioning to the patients and doctors. The new system also has higher capacity, paving the way for increased load as PSRI continue to increase its service offerings.