POWER SAVING SCHEMES IN THE NSRRC

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Abstract

To cope with increasing power cost and to confront huge power consumption of the Taiwan Photon Source (TPS) in the future, we have been conducting several power saving schemes since 2006 in the National Synchrotron Radiation Research Center (NSRRC). Those power saving schemes include optimization of chiller operation, air conditioning system improvement, power factor improvement and the lighting system improvement.

INTRODUCTION

NSRRC has conducted some major projects and upgraded the utility system for better beam stability for years [1],[2]. We have greatly improved stabilities of the electrical power, cooling water and air conditioning systems. On the other hand, the electrical power consumption is also increased. The contract power capacity between NSRRC and Taiwan Power Company (TPC) had been increased from 3500 kW in 2000, 4500 kW in 2002 to 5500 kW currently.

Furthermore, we estimate the on-going project of 3.0 GeV, 518m in circumference, low emittance and high brightness TPS requires over twice power consumption than that in TLS. Also, the power bill of per kW-hr was increased about 35% last year. Figure 1 shows the monthly average power bill per kW-hr in NSRRC from 2006 to 2009. All the monthly average power bills per kW-hr in NSRRC from Jan. 2006 to July 2009 are less than NT$ 2.0. The number in Aug. 2009 abruptly jumped to NT$ 2.34. The number of Feb. 2009 even came to NT$ 2.55. Confronting fast growth of the power consumption and huge increase in power bill, NSRRC has been conducting a series of power saving schemes since 2006. Those power saving schemes basically include four parts, i.e., 1. optimization of chiller operation, 2. air conditioning system improvement, 3. power factor improvement and 4. the lighting system improvement. All the schemes are described as follows.

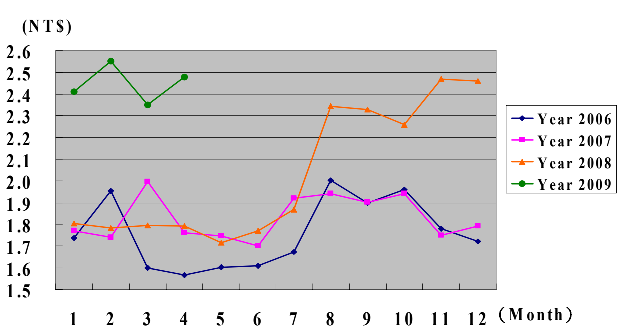

Figure 1: Monthly average power bill per kW-hr in NSRRC from 2006 to 2009.

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OPTIMIZATION OF CHILLER OPERATION

Among all electrical power loads in NSRRC, chillers are the most power consuming equipment and consume about 30% of the total power consumption. Thus, optimization of the chiller operation usually can save most power.

Because the chilled water piping system between two buildings i.e., Administration and Research (AR) and Instrument Development (ID) buildings had been connected, we take the operation of chiller operation between these two buildings as an example. Currently, there are two 200 RT chillers equipped in the AR building and one 500 RT and one 200 RT chillers are equipped in the ID building. All those three 200 RT chillers were installed in 1990. The 500 RT chiller was installed in 2005. As the chilled water piping systems of these two buildings are merged, those chillers can support one another.

We ever measured the power loads of two 200RT chillers i.e., PM-S1A and PM-S1B in AR building as 56% and 54% in 2006, respectively. Meanwhile, the power load of the 500 RT chiller PM-M1A was measured as 48%. The operation efficiencies of these three chillers were measured as 1.29 kW/RT, 1.08 kW/RT and 1.10 kW/RT, respectively then. Practically, the most efficient operation point of the power load of a chiller locates on the range of 70%-90%. After load estimation, we changed the chiller operation. We only run the 500RT one, PM-M1A instead of simultaneous running those three chillers i.e., PM-S1A, PM-S1B and PM-M1A. The result of this change showed the power load and the operation efficiency of the chiller PM-M1A were 92% and 0.65 kW/RT, respectively. The efficiency was enhanced almost double.

Figure 2 shows the power consumption of AR and ID buildings before and after the chiller operation change. There is one electrical power feeder for the AR building, in red color, and two feeders A and B for the ID building, in green and blue colors, respectively. The average electrical power consumption in AR building before the change of chiller operation was about 550kW. And those numbers of two feeders A and B for the ID building before the change of chiller operation were about 200 kW and 300 kW, respectively. After the change of chiller operation, the average electrical power consumption reduced to about 250 kW, and those numbers of two feeders A and B for the ID building were about 150kW and 400 kW, respectively. Thus, the total electrical power consumption for these two buildings was reduced about 250 kW due to the optimization of chiller operation.

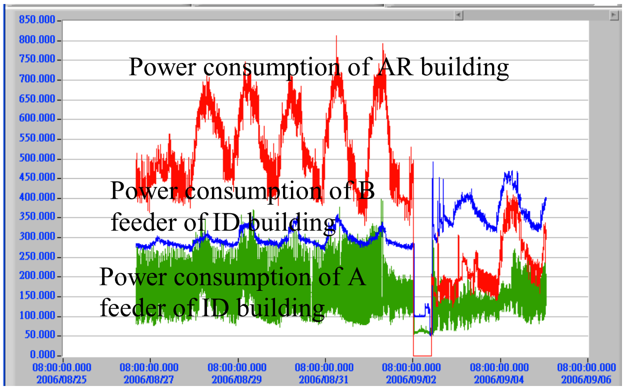

Figure 2: Power consumption of AR and ID buildings before and after the chiller operation change.

According to the successful experience of the optimization of chiller operation, NSRRC then merged chilled water piping systems between other two buildings, 1st and 2nd Utility buildings in 2007. Currently, there are three 320 RT chillers equipped in the 1st Utility building and two 450 RT and two 600 RT chillers equipped in the 2nd Utility building. Therefore, the merge scheme provides more options of chiller operation. We also installed flow meters and electrical power meters on those seven chillers to online monitor their performances. Figure 3 shows the monitor page of the designed performance curves and actual online operation points of the seven chillers. This monitor page is built in the control system to check if the running chiller is on normal operation. After merge of chilled water piping systems and the optimization of chiller operation between the 1st and the 2nd Utility buildings, the total electrical power consumption of these two buildings was reduced about 350 kW.

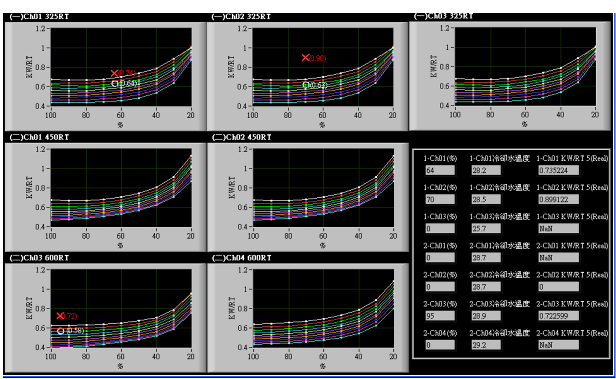

Figure 3: Monitor page of the designed performance curves and actual online operation points of the seven chillers.

A/C SYSTEM TIMER CONTROL AND APPLICATION OF INVERTERS

We applied timer control on the air conditioning system according to power consumption in various hours to obtain efficient operation. Figure 2 also illustrates the electrical power consumption conditions on the day and night time. It also shows that the power consumption on the weekend (Sep. 2-3 2006) was relatively low.

Also, the power saving performance of frequency inverters of air handling units (AHU) was tested in 2006. The test results showed that power consumptions of those 14 AHUs with and without frequency inverter running were 1800 kW-hr and 2900 kW-hr, respectively. Accordingly, we installed 15 frequency inverters on those AHUs. It cost about NT$ 1.6 million and saved about 1200 kW-hr.

IMPROVEMENT OF TEMPERATURE AND HUMIDITY CONTROL

We once found a chasing phenomenon between the control of chilled water and hot water. Consequently, it resulted in severe fluctuation of the openings of chilled water and hot water valves, as shown in Figure 4.

The fluctuation range was about ±10%. The average openings of chilled water and hot water valves were also relatively high, about at 80% and 55%, respectively. The humidity was relatively low (about 35%) in the air conditioned room accordingly. After our control adjustment, the openings of chilled water and hot water valves were decreased to about 30% and 45%, respectively. The flow rates of both chilled water and hot water were thus reduced. The reduced flow rate of chilled water was about 400GPM. The room temperature and humidity were successfully kept at the set points.

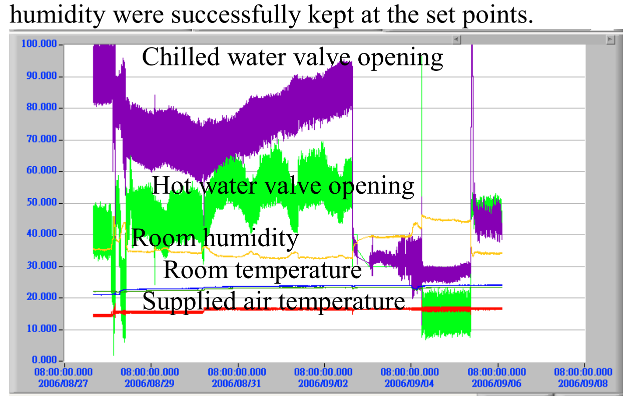

Figure 4: Improvement of temperature and humidity control.

APPLICATION OF THE HEAT PUMP

NSRRC always used electrical heated water on the air conditioning system and de-ionized water to control temperature before. However, the coefficient of performance (COP) of the general electrical heater is only about 90%. It means per kW-hr can produce about heat of 774 kcal. For better COP, we installed a new heat pump in the machine room of the 2nd Utility building last year. The COP of the heat pump is about 350%, which is almost 4 times that of the electrical heater. The heat pump absorbs waste heat from air to the hot water. Thus it can save electrical power as well as provide cooled air to the machine room.

ELECTRICAL POWER FACTOR IMPROVEMENT

We put many efforts on the improvement in the electrical power factor these years. We applied power factor correction capacitor bank to improve the power factor as well as reduce power losses (I^2R).

Figure 5 shows the yearly average power factors of past 5 years. The yearly average power factor was improved from 95.08% in 2004 to 99.92 in 2008. The TPC also rewards power users with discount of power bill for their efforts on good power factor. The saved power bill was also increased from NT 1,200,298 dollars in 2004 to NT 2,308,423 dollars in 2008.

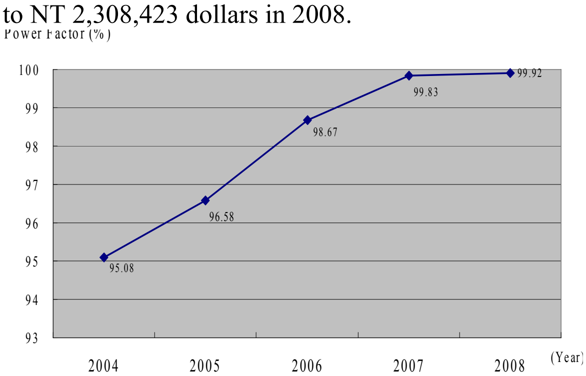

Figure 5: Yearly average power factors of past 5 years.

LIGHTING SYSTEM IMPROVEMENT

Three years ago, most lighting equipments in NSRRC had been used for 16 years. Those old lighting equipments mostly were equipped with traditional ballasts and seldom designed for power saving purpose. We had replaced those traditional ballasts by electronic ones in 1996. Many old lighting equipments were also eliminated. There were 800 fluorescent tubes of 40 kW, for example, replaced by 32 kW ones.

Besides, we also modified switches of some lighting systems for power saving purpose. For example, we added a lighting switch of the area of the storage ring tunnel on the control room last year so that the lighting may be turned off once the beam was started to be operated. This scheme saved about 30 kW.

POWER SAVING RESULTS

The costs and payoff periods of all above power saving schemes are listed in Table 1. Among all schemes, optimization of chiller operation costs zero and saves most electrical power. This is the case for the AR and ID buildings. Schemes AHU timer control and temperature and humidity control also cost zero because those control systems had been originally equipped. The scheme with the longest payoff period, 26.7 months, is the application of frequency inverter on the AHUs. Other detailed data are also listed in Table 1. However, those saved power bills are calculated based on NT$ 2.0/kW-hr. This number has been increased about 25% currently. It means the payoff period may be shortened 25% today.

Table 1: Cost and payoff period of each scheme

Power saving scheme	Cost (1000NT)	Save bill (NT per month)	Payoff period (month)
Chiller operation	0	300,000	NA
AHU timer	0	150,000	NA
Inverter for AHU	1,600	60,000	26.7
Temp. control	0	150,000	NA
Heat pump	4,000	216,000	18.5
PF improvement	500	35,000	1.4
Lighting change	450	23,570	19

Figure 6 shows monthly power consumptions of latest 4 years. Power consumptions on Feb. or March are relatively low due to the annual long shutdown.

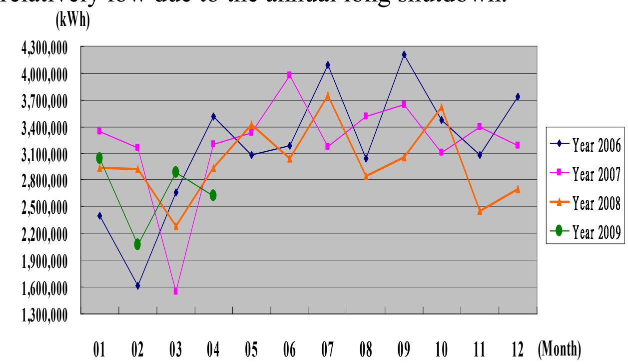

Figure 6: Monthly power consumptions of recent 4 years.

Table 2 lists accumulated power consumptions of recent 6 years. The growth rates of power consumption of past 4 years are 17.8%, 2.7%, 1.3% and -6.7%. The growth rate of power consumption of this year also shows negative so far. The overall power saving result is remarkable.

Table 2: Accumulated power consumptions of recent 6 years.

	Accumulated power (Jan.-Apr., MW-hr)	Accumulated power (whole year, MW-hr)
2004	7,888	31,464
2005	10,340	37,080
2006	10,184	38,096
2007	11,248	38,576
2008	11,096	35,984
2009	10,616	

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