POWER SAVING SCHEMES IN THE NSRRC

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Abstract

To cope with increasing power consumption and huge power bill of the Taiwan Photon Source (TPS) in the near future, we have been conducting several power saving schemes at National Synchrotron Radiation Research (NSRRC). The power saving schemes presented in this paper includes raising air conditioning temperature setting, modification of power bill calculation mode, power consumption control, electrical power factor improvement, and promotion of power saving.

INTRODUCTION

NSRRC has been conducted some major projects, including installation of superconducting rf cavities and magnets, construction of extending buildings in the Taiwan Light Source (TLS) for years. Also, the civil construction of the TPS project has also been started since 2010. Electrical power consumption is highly increased consequently. The contract power capacity between NSRRC and Taiwan Power Company (TPC) has been increased from 3.5 MW in 2000 to 5.5 MW currently.

Besides, the full power requirement of the constructing TPS ring, with 3.0 GeV, 518m in circumference, is estimated about 12.5 MW. The utility building for the TPS will be completed in the end of 2012. Another 1.0 MW power capacity for the TPS will be contracted with TPC then.

Furthermore, the power bill of per kW-hr was increased about 35% in 2008. It will be increased about 40% in June 2012 according to the estimation from TPC. Figure 1 shows the monthly average power bill per kW-hr in NSRRC from 2008 to May 2012.

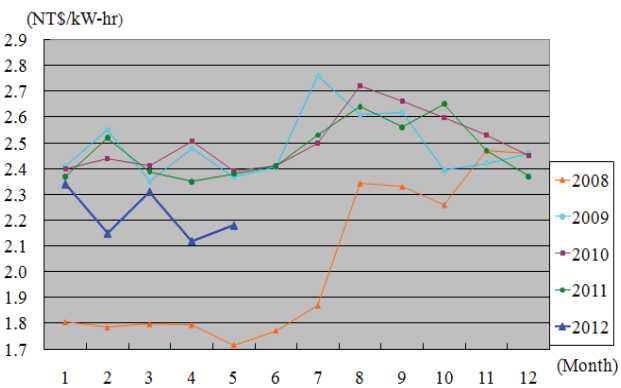

Figure 1: Monthly average power bill per kW-hr in NSRRC from 2008 to 2012.

To cope with fast growth of the power consumption, NSRRC has been conducting a series of power saving schemes since 2006 [1] [2]. Those power saving schemes include optimization of chiller operation, power consumption control, improvement of temperature and humidity control, electrical power factor improvement, lighting system improvement, application of heat pumps and. We keep conducting those schemes and create some new ones, including raising air conditioning temperature setting, modification of power bill calculation mode and promotion of power saving. Some major schemes are described as follows.

RAISING AIR CONDITIONING TEMPERATURE SETTING

For installing two new cooling towers for the TPS project, we removed an old one for the TLS from its location in April 2012. Due to the limitation of cooling capacity, we raised the air conditioning temperature setting by 2 °C in the TLS experimental hall.

Figure 2 shows the supplied air temperature from the air handling unit (AHU) and power consumption histories before and after raising the air temperature setting. The supplied air temperature from AHU was raised from 15.8 °C to 17.8 °C at 9:00 AM 3/19/2012, as the green line shown in Figure 2. The load of chillers was consequently reduced. The white and red lines in Figure 2 are power consumption of two main power feeders A and B, respectively. As shown in the figure, the power consumption of feeder A was reduced about 190 kW and that of feeder B was increased about 10 kW. This is because the chillers of which power supplied from feeder A were shutdown and chillers of which power supplied from feeder B were started. Therefore, about 180 kW was reduced.

Figure 2: Supplied air temperature from AHU and power consumption histories before and after raising the air temperature setting.

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MODIFICATION OF POWER BILL CALCULATION MODE

There are two modes of power bill calculation for industrial power customers according to the rule of TPC. One is so called "two time periods" mode and the other is "three time periods" mode. The main difference between these two modes is on the power bill calculation on week day. The former mode divides one day into peak hours and off-peak hours. The latter mode divides one day into peak hours, semi-peak hours and off-peak hours. These power bill calculation modes are designed for the consideration of limited power reserve margin. NSRRC had applied the "two time periods" mode of power bill calculation for years. We changed the power bill calculation mode to the "three time period" on Jan. 2012.

Due to the modification of power bill calculation mode, the monthly average power bill per kW-hr of 2012 is clearly reduced compared with those of 2009 to 2001, as shown in Figurer 1.

Although the scheme of modification of power bill calculation mode does not save power, it saves much money. So far it saved the power bill total 3,240,686 NT dollars (about $110,000 dollars) from Jan. to May 2012. Also, this scheme helps TPC to plan and provide electircal power efficiently.

POWER COMSUMPTION CONTROL

Like the scheme of modification of power bill calculation mode, the scheme of power consumption control helps TPC to plan and provide electircal power efficiently. This scheme also saves power.

"Contract power capacity" is an important index of power bill cost. Setting an optimized contract power capacity can not only save power bill, but also provide accurate data for TPC. There are penalty rules for power costumers once their power consumption is over the contract capacity. Thus, power customers are suggested to control their power consumption less than the contract power capacity.

Although the electrical power consumption has been largely increased for years in NSRRC, we still keep the contract capacity on 5.5 MW since 2006. Figure 3 shows monthly peak power consumption in NSRRC from 2008 to 2012. Because of hot weather and power consumption of TPS construction added, the peak power consumptions of past two summers were over contract capacity. Especially in July 2010, the peak power consumption was as high as 6,200 kW. Although the situations of hot weather and added power consumption of TPS construction are the same as summer 2010, we have reduced the peak power consumption last summer, as shown in Figure 3. Due to rf system of TPS test, the peak power consumption in Jan 2012 reached to 6,000 kW.

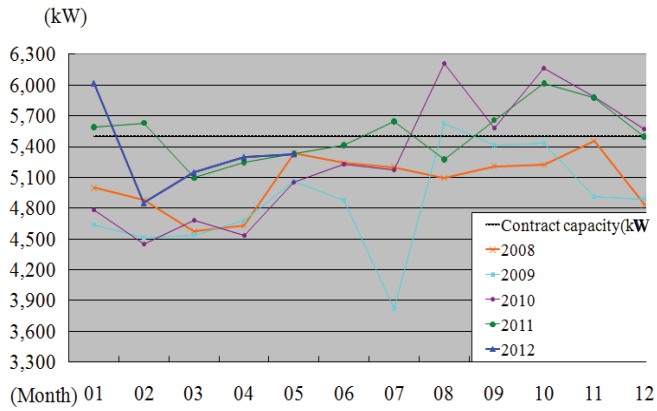

Figure 3: Monthly peak power consumption in NSRRC from 2008 to 2012.

ELECTRICAL POWER FACTOR IMPROVEMENT

We have kept improving in the electrical power factor since 2004. We applied power factor correction capacitor bank to improve the power factor as well as reduce power losses (I2R).

The yearly average power factor was improved from 95.08% in 2004 to 100.00 in 2010. The TPC also rewards power customers with discount of power bill for their efforts on good power factor control. The saved power bill was also increased from NT 1,200,298 dollars in 2004 to NT 2,978,911 dollars in 2011, as shown in Figure 4.

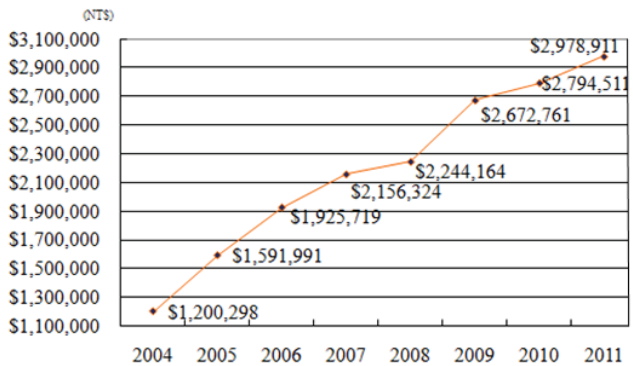

Figure 4: Power bill saved because of power factors improvement for past 8 years.

PROMOTION FOR POWER SAVING

To supervise the power saving works, NSRRC had formed a power saving committee and held the first meeting in Nov. 2011. Some action items of promotion for power saving had been assigned then. One of them is to display the real time information of total power consumption in NSRRC and each building on the public screen for the beam quality. This work had been accomplished in April 2012, as shown in Figure 5.

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Figure 5: Power consumption of NSRRC and each building displayed on the public screen.

In charge of the electrical power system and power control, we have published monthly power saving report to all staff and all users in NSRRC since July 2008. The monthly report includes power consumption and power bill from TPC of that month, of the same month last year, and of last month, and power saving project and status report.

Figure 6 shows the power consumption of May 2012 in the latest monthly report. The history data were recorded from 29th March to 27th April, according to the period of the power bill.

There are two feeders A and B from TPC to NSRRC, respectively shown in white and red color in Figure 7. The sum of these two feeders is shown in green color. The total power consumption was control within 5,500 kW, contract capacity, in the whole month.

The power consumptions of four weekends were clearly reduced than peak time.

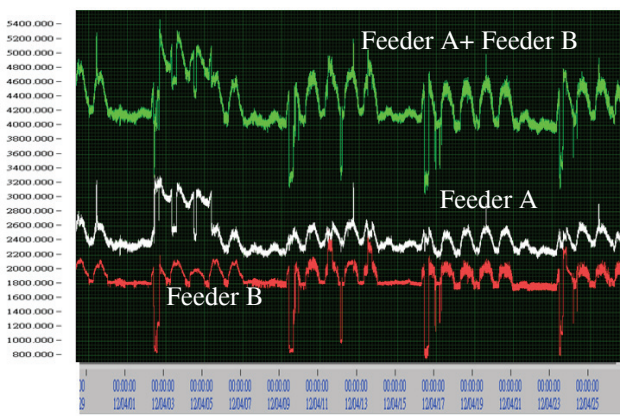

Figure 6: Power consumption of May 2012 in the latest monthly report.

APPLICATION OF HEAT PUMPS

NSRRC formally used electrical heated water on the air conditioning system and de-ionized water to control temperature. 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 in 2008. 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.

In the TPS project, we will install two more heat pumps in the 3rd Utility building in the end of 2012. The type of heat pump absorbs waste heat from water to hot water. The COP of these two heat pumps is similar to the one installed in the 2nd Utility building.

POWER SAVING RESULTS

The costs and payoff periods of all above power saving schemes are listed in Table 1. Among all schemes, raising air temperature, modification of power bill calculation mode, power consumption control, and promotion for power saving cost zero. The scheme with the longest payoff period, 17 months, is the application of the heat pump. Those saved power bills are calculated based on NT$ 2.2/kW-hr.

Table 1 Cost and payoff period of each scheme

Power saving scheme	Cost (1000NT)	Save bill (NT /month)	Payoff period (month)
Raising air temp.	0	316,000	NA
Power bill calculation mode	0	648,000	NA
Power control	0	40,000	NA
Heat pump	4,000	216,000	17
PF improvement	500	35,000	1.3
Promotion	0	0	NA

The growth rates of power consumption of past 4 years are -6.7%, -3.0%, 3.7%, and 7.3% respectively. The growth rates of power consumption of 2010 and 2011 became positive because of the TPS construction.

ACKNOWLEDGEMENT

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