POWER SAVING STATUS IN THE NSRRC

J.C. Chang*, T.S Ueng, Z.D. Tsai, Y.C. Lin, C.Y. Liu, Y.C. Chung, and Y.F. Chiu
National Synchrotron Radiation Research Center (NSRRC), Hsinchu 30076, Taiwan

Abstract

National Synchrotron Radiation Research Center (NSRRC), Taiwan will complete the construction of the civil and utility system engineering of the Taiwan Photon Source (TPS) in the end of 2012. The power consumption of the TPS is estimated about 2.3 times of that of the existing Taiwan Light Source (TLS). To cope with increasing power requirement in the near future, we have been conducting several power saving schemes, which include power requirement control, optimization of chillers operation, air conditioning system improvement, power factor improvement, application of heat pump, and publishing monthly power saving report.

INTRODUCTION

As NSRRC conducted some major projects, including installation of superconducting rf cavities and magnets and construction of extending buildings for past decade, the electrical power consumption also greatly increased. 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 2011. Another 1.0 MW power capacity for the TPS will be contracted with TPC then. Also, the power bill of per kW-hr was increased about 35% in 2008. Figure 1 shows the monthly average power bill per kW-hr in NSRRC from 2006 to 2011.

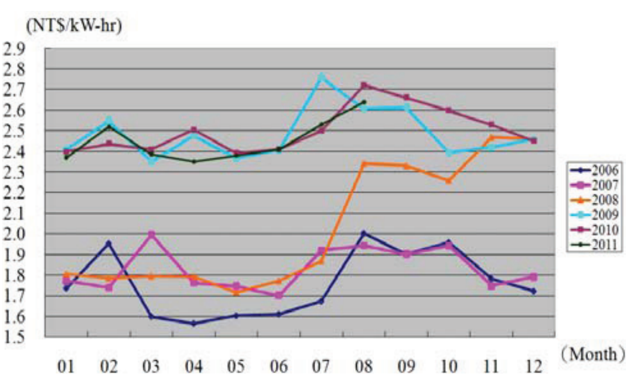

Figure 1: Monthly average power bill per kW-hr in NSRRC from 2006 to 2011.

To cope with fast growth of the power consumption, NSRRC has been conducting a series of power saving schemes since 2006 [1]. Those power saving schemes basically include four parts, i.e., 1. power consumption control, 2. optimization of chiller operation, 3. electrical power factor improvement, 4. application of heat pumps and 5. publishing monthly power saving report. All the schemes are described as follows.

POWER COMSUMPTION CONTROL

"Contract power capacity" is an important index of power bill control. 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 should control power consumption not over 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 2 shows monthly peak power consumption in NSRRC from 2006 to 2011. Because of hot weather and power consumption of TPS construction added, the peak power consumptions last summer were over contract capacity. Especially in last July (bill month was August, as shown in Fig. 2), 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 last July, we have controlled the peak power consumption within the contract capacity this July, as shown in Figure 2.

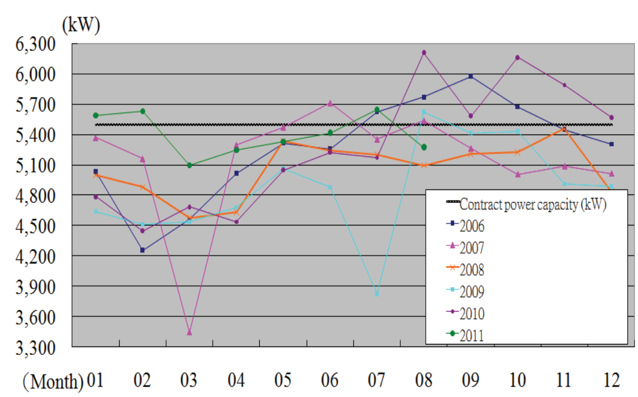

Figure 2: Monthly peak power consumption in NSRRC from 2006 to 2011.

OPTIMIZATION OF CHILLER OPERATION

In most facility, air conditioning and cooling water are the most power consuming system. Among all electrical power loads in NSRRC, chillers are the most power consuming equipment. It occupies about 30% of the total power consumption.

* E-Mail: jcchang@nsrrc.org.tw

We conducted the optimum chiller operation in the Instrumentation Development (ID) building. Currently, there are one 200 RT, labelled as PM-M1A, and one 500 RT, labelled as PM-M1B, chillers equipped in the ID building. Normally, chillers PM-M1A and PM-M1B respectively run in the off-peak time and peak time. We had set automatic transfer control between PM-M1A and PM-M1B. Formally, once the power load of PM-M1A was over 92% for 15 minutes, the running chiller would be switched to PM-M1B. On the other hand, once the power load of PM-M1B is less than 50%, the running chiller would be switched to PM-M1A. Typically, chiller PM-M1A and PM-M1B usually run at power load of 70%-90% and 50%-60%, respectively. Practically, the most efficient operation point of the power load of a chiller locates on the range of 70%-90%. Thus, PM-M1A run more efficiently and PM-M1B consumed more power.

After load estimation, we lifted criterion of switching PM-M1A to PM-M1B by increase the power load of PM-MIA from 92% to 95%. Consequently, chiller PM-M1A run all the time. Figure 3 shows power consumption of ID building before and after the chiller operation change. There is one electrical power feeder A for chiller PM-M1A, in white color in the upper figure, and one feeder B for chiller PM-M1B, in red color in the lower figure, respectively. There is a vertical yellow straight line showing the time we changed the chiller operation control. These data are history from 1st to 17th July 2011. There are two segments respectively in 7/2~7/3 and 7/9~7/10 are the weekends.

Clear daily period of power consumption is shown in the weekdays. Especially in feeder B, square-like waves of 300 kW in amplitude appear in the daytime. Before the chiller operation control change, the power consumption in the peak time in feeder A and B were about 200kW and 430kW, respectively. After the control change, the power consumption in the peak time in feeder A and B were about 320kW and 200kW, respectively. Thus, total about 110kW of power was saved because of the control change.

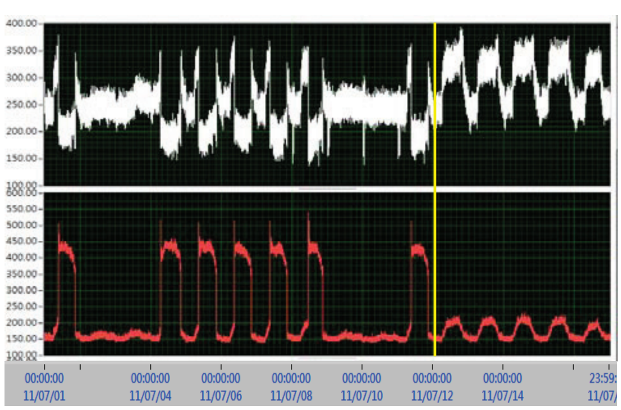

Figure 3: Power consumption of ID building before and after the chiller operation control change.

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).

Figure 4 shows the yearly average power factors of past 7 years. The yearly average power factor was improved from 95.08% in 2004 to 100.00 in 2010. 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 2,794,511 dollars in 2010, as shown in Figure 5.

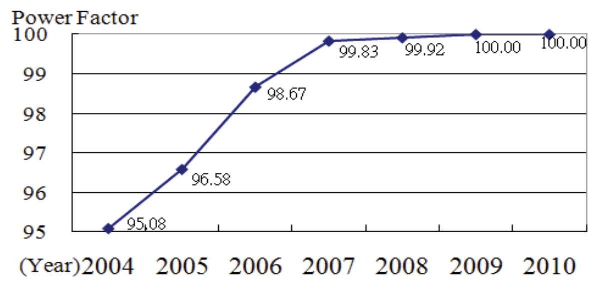

Figure 4: Average power factors for past 7 years.

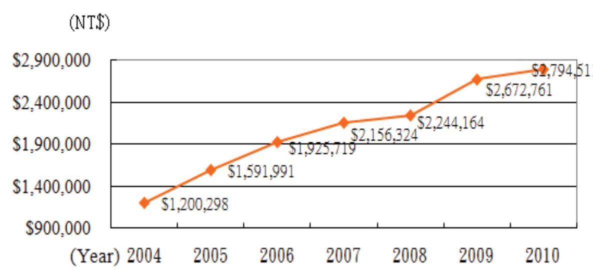

Figure 5: Power bill saved because of power factors improvement for past 7 years.

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. 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.

PUBLISHING MONTHLY POWER SAVING REPORT

In charge of the electrical power system and power control, we had published monthly power saving report to all staff and users in NSRRC since July 2008. The monthly report includes 1. power consumption and power bill from TPC of that month, 2. power consumption and power bill from TPC of the same month last year, 3. power consumption and power bill from TPC of last month, and 4. power saving project and status report.

Figure 6 shows the power consumption of July 2011 in the latest monthly report. The history data were recorded from 28th June to 27th July, according to the period of the power bill.

There are two feeders A and B from TPC to NSRRC, respectively shown in black and green color in Figure 6. The sum of these two feeders is shown in pink color. Generally, the total power consumption was control within 5,500 kW in the whole month.

The accelerator was scheduled shutdown from 18th to 22nd July. During machine shutdown, the power consumptions of feeder A and B were reduced about 200 kW and 1150 kW, respectively.

The power consumptions of four weekends were also clearly reduced than peak time in Figure 6. The power consumption of ID building before and after the chiller operation control change shown in Figure 3 is also shown in Figure 6.

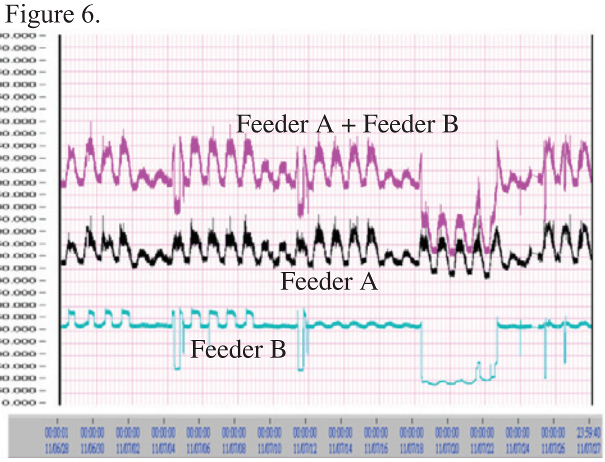

Figure 6: Power consumption of July 2011 in the latest monthly report.

POWER SAVING RESULTS

The costs and payoff periods of all above power saving schemes are listed in Table 1. Among all schemes, power consumption control, optimization of chiller operation and publishing monthly power saving report cost zero. The scheme with the longest payoff period, 18.5 months, is the application of the heat pump. 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 30% currently. It means the payoff period may be shortened 30% today.

Table 1 Cost and payoff period of each scheme

Power saving scheme	Cost (1000NT)	Save bill (NT per month)	Payoff period (month)
Power control	0	40,000	NA
Chiller operation	0	50,000	NA
Heat pump	4,000	216,000	18.5
PF improvement	500	35,000	1.4
Monthly report	0	0	NA

Figure 7 and 8 show monthly and season power consumptions of recent 6 years, respectively. Power consumptions on Feb., March or the first season are relatively low due to the annual long shutdown.

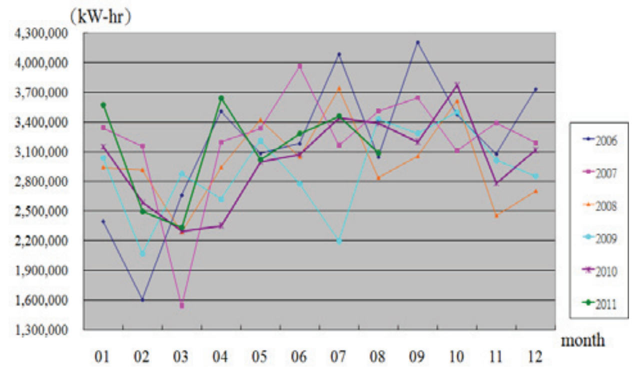

Figure 7: Monthly power consumptions of recent 6 years.

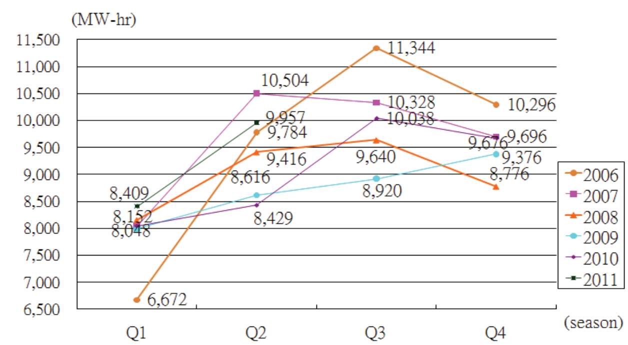

Figure 8: Season power consumptions of recent 6 years.

The growth rates of power consumption of past 5 years are 2.7%, 1.3%, -6.7%, -3.0% and 3.7%, respectively. The growth rates of power consumption of former four years are kept decreased. The growth rate of power consumption of 2010 became positive because of the TPS construction.

ACKNOWLEDGEMENT

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REFERENCES

[1] J.C. Chang, et al., "Power Saving Schemes in The NSRRC" The 23rd Particle and Accelerator Conference (PAC), Vancouver Canada, May 4-8, 2009.