# POWER SAVING STATUS IN THE NSRRC

J.C. Chang*, T.S Ueng, Z.D. Tsai, Y.C. Lin, C.Y. Liu, Y.C. Chung, Y.F. Chiu, and C.W. Hsu
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 2013. 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. We will also connect the main pipes of TLS and TPS chilled water systems to obtain more efficient operation in 2013.

## 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 completed on April 2013. 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 had been completed in the end of 2012. Another 1.0 MW power capacity for the TPS had also been contracted with TPC then.

Furthermore, the power bill of per kW-hr was increased about 35% in 2008. It had been increased about 40% in June 2012, as shown in Figure 1, monthly average power bill per kW-hr in NSRRC from 2009 to May 2013. There will be another increased about 40% in Oct. 2013 declared by TPC.

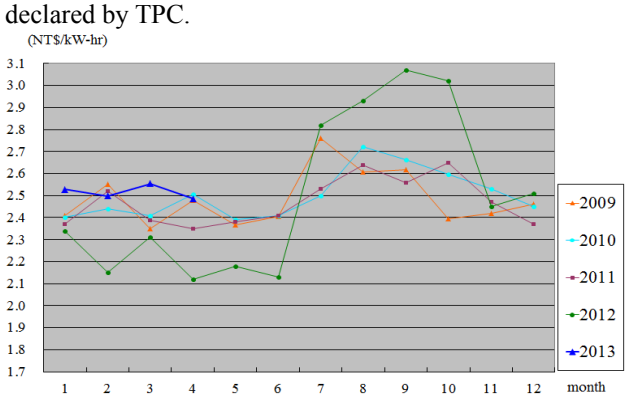


Figure 1: Monthly average power bill per kW-hr in NSRRC from 2009 to 2013.

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 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 modification of power bill calculation mode, the second phase lighting system improvement and promotion of power saving. Some major schemes are described as follows.

## 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 Figure 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 5,967,572 NT dollars (about $200,000 dollars) in 2012. Figure 2 shows the power bill saved due to modification of power bill calculation mode in 2012.

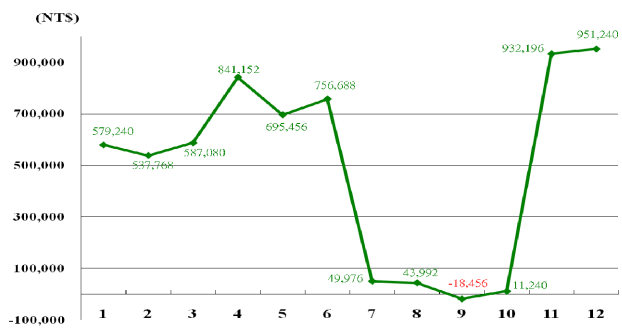


Figure 2: Power bill saved due to modification of power bill calculation mode in 2012.




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## POWER COMSUMPTION CONTROL

"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.

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. Moreover, this scheme also saves power.

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 2009 to 2013. 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.

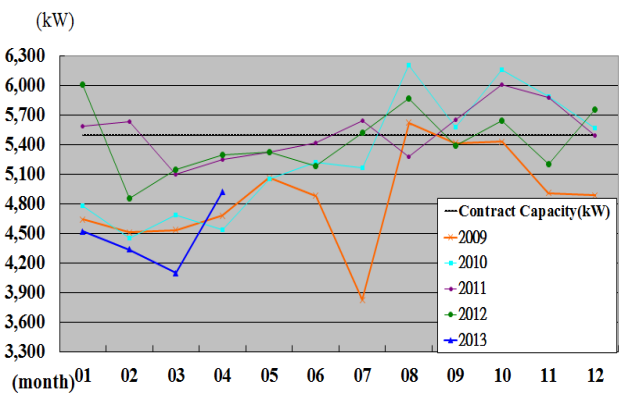


Figure 3: Monthly peak power consumption in NSRRC from 2009 to 2013.

## 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 2,896,322 dollars in 2012, as shown in Figure 4.

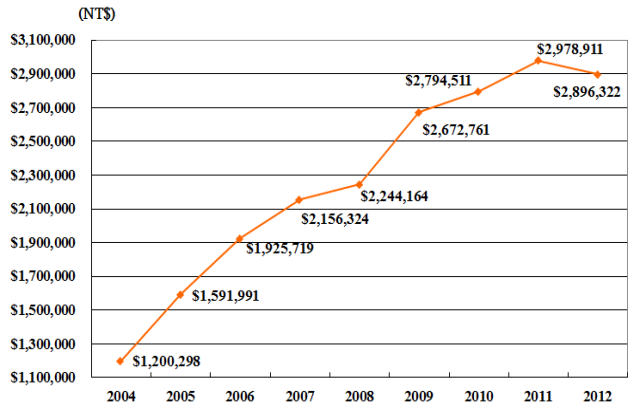


Figure 4: Power bill saved because of power factors improvement for past 9 years.

## LIGHTING SYSTEM IMPROVEMENT

We had replaced those traditional ballasts by electronic ones in past years. Some old lighting equipment was also eliminated. The traditional T9 fluorescent tubes of 40 kW had been replaced by T5 tubes. This scheme is kept in process until all the traditional tubes are replaced. We also choose T5 tubes in the TPS project.

We had installed sensors and light controllers on the public area. The light will be turn off on off time. Once someone passes by, the light will be turn on automatically.

Besides, we removed 30 mercury lamps of 400 W in the TLS experimental hall in 2012. Figure 5 shows the 30 removed mercury lamps. Twenty mercury lamps marked in pink color and 10 ones marked in red were removed in the first and second phases, respectively. The mercury lamps were removed in two phases. The scheme saved about $10,000 dollars.

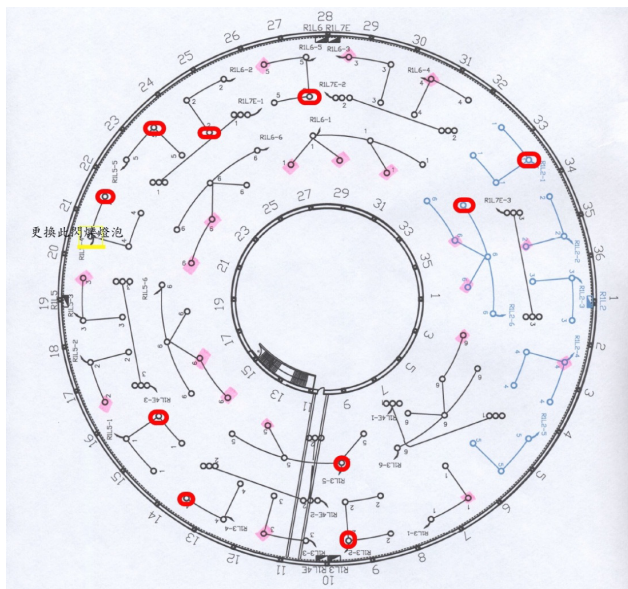

Figure 5: Thirty removed mercury lamps in the TLS experimental hall.



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## 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 in the meeting. 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.

In charge of the electrical power system and power control, we have published monthly power saving report to all staffs and 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 April 2013 in the latest monthly report. The history data were recorded from 26th Feb. to 27th March, 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 6. 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, as shown in the figure.

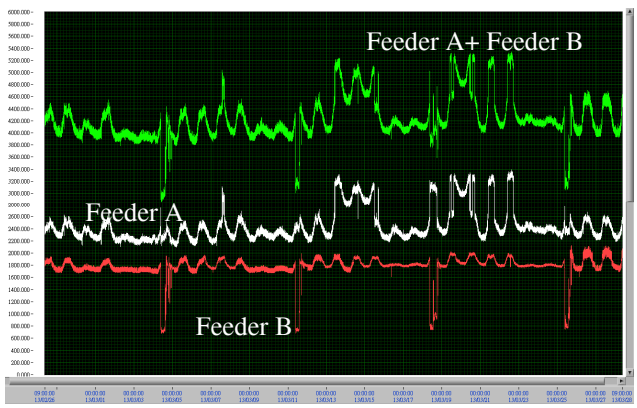


Figure 6: Power consumption of April 2013 in the latest monthly report.

## 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 had installed 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.

## CHILLED WATER PIPES CONNECTION BETWEEN TPS AND TLS

There are three utility buildings in NSRRC. The first one was constructed for the TLS 20 years ago. There are three chillers, each with 320 RT in capacity installed inside. The second Utility Building was construction for the cryogenics and superconductivity systems 10 years ago. There are two 600 RT chillers and two 450 RT chillers installed inside. We ever connected chilled water pipes between the first and the second Utility Buildings. It saved about 70 kW.

The civil construction 3rd Utility building for the TPS had been completed in Dec. 2012. Three chillers, each with 1,400 RT in capacity, had been installed inside. We will connect the chilled water pipes between the second and the third Utility Buildings this year. The construction bid will be contracted out in May 2013.

## POWER SAVING RESULTS

After we conducted those the power saving project these years, the power saving results are notable. The growth rates of power consumption and power bill of last years are -4.5% and -3.1, respectively. The growth rates of power consumption of 2010 and 2011 became positive because of the TPS construction. Table 1 shows power consumption and power bill from 2007 to 2012.

Table 1: Power Consumption and Power Bill From 2007 to 2012

| | Power consumption (kWH) | Growth Rate(%) | Power Bill(NT$) | Growth Rate(%) |
|---|---|---|---|---|
| 2007 | 38,576,000 | 1.26% | 70,257,061 | 5.14% |
| 2008 | 35,984,000 | -6.72% | 72,833,042 | 3.67% |
| 2009 | 34,904,000 | -3.00% | 86,474,726 | 18.73% |
| 2010 | 36,189,681 | 3.68% | 90,439,577 | 4.58% |
| 2011 | 38,816,103 | 7.26% | 95,384,714 | 5.47% |
| 2012 | 37,068,071 | -4.50% | 92,444,282 | -3.1% |

## 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.




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