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POWER SAVING STATUS IN THE NSRRC

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Abstract

National Synchrotron Radiation Research Center (NSRRC), Taiwan has completed the construction of the civil and utility system engineering of the Taiwan Photon Source (TPS) in 2013 and 2014, respectively. The contract power capacities of the Taiwan Light Source (TLS) and the TPS with the Taiwan Power Company (TPC) are 5.5MW and 3MW currently, respectively. The ultimate power consumption of the TPS is estimated about 12.5MW. To cope with increasing power requirement in the near future, we have been conducting several power saving schemes for years. They include power consumption control, optimization of chillers operation, air conditioning system improvement, power factor improvement, application of heat pump, and promotion for power saving.

INTRODUCTION

NSRRC has been conducted some major projects, including installation of superconducting rf cavities and magnets, construction of extension buildings in the Taiwan Light Source (TLS) for years. Also, the civil construction of the TPS project has also been completed in 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.

The power bill was also raised three times during 2008 to 2013. The power bill of per kW-hr was increased about 35%, 40%, and 10% in 2008, June 2012, and Oct. 2013, respectively. Figure 1 shows monthly average power bill per kW-hr in NSRRC from 2008 to 2014.

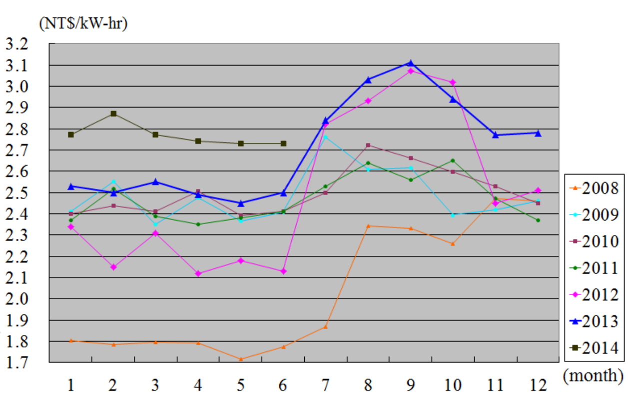

Figure 1: Monthly average power bill per kW-hr in NSRRC from 2008 to 2014.

Besides, the full power requirement of the TPS is estimated about 12.5 MW. The utility building for the TPS had been completed in the end of 2012. Currently, the contract capacity of TPS is 3.0 MW. Because the booster and LINAC will be tested soon and the summer is coming, the contract capacity of TPS will be increased to 4 MW this summer.

To cope with fast growth of the power consumption and power bill, 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, and application of heat pumps. We keep conducting those schemes and create some new ones, including modified run-around coil AHU, change of power bill calculation mode, and promotion of power saving. Some major schemes are described as follows.

RUN-AROUND COIL HEAT RECOVERY

Typically, an air AHU is equipped a cooling and a heating finned-tube coils to reduce air temperature and moisture then heat air temperature to the set point. We proposed additional run-around coil loop applied in the AHU to play a role in heat recovery and power saving in 2012 [2].

Figure 2 shows the run-around coils. There are four heat exchangers, i.e. pre-cooling (P/C), cooling (C/C), pre-heating (P/H) and heating (H/C) coils. To keep a room in suitable humidity, the temperature of the air flow through the cooling coil is controlled at 13 °C. The temperature of air flow through the heating coil is controlled at 21 °C, within ± 0.1 °C. The data shown in Figure 2 are collected from measurement.

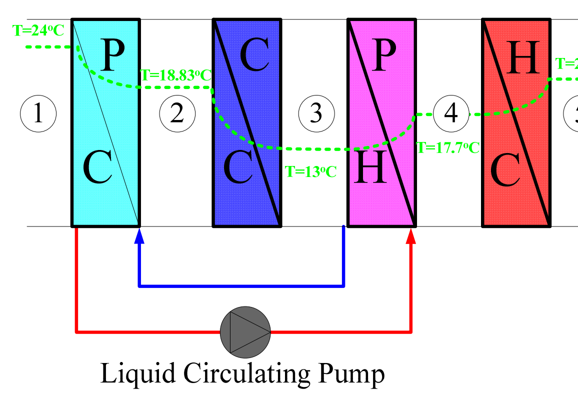

Figure 2: Run-around coils.

The pre-cooling coil and the pre-heating coil are connected with a circulated pipe to form a loop for water circulation. A small pump is installed in the loop to circulate the heated water from the pre-cooling coil to the pre-heating coil.

Sensible heat withdrawn from the warm air on its way to the pre-cooling coils is carried by the circulating water to the pre-heating coils. The latter coils then return the sensible heat to the chilled air leaving the pre-heating coils. Any sensible heat added to the air flow by the pre-heating coils is equal to the heat removed by the pre-cooling coils.

In the experiment, without run-around mode, the original flow rates of the chilled and hot water were 120 and 95 LPM, respectively. After the pump was turned on, the flow rates of the chilled and hot water decreased to 80 and 35 LPM, respectively. Therefore, 33 % and 63 % flow rates for the chilled and hot water were decreased, respectively. The power of the circulating pump was estimated to be about 3 % while the energy consumed by the cooling and heating coils was decreased by 53 %. Much energy was thus saved.

Moreover, we modify the run-around coil heat recovery system by removing the small pump. Figure 3 shows the modified run-around coils. By using the secondary pump form the chiller, the supplied chilled water flows through the cooling coil, pre-cooling coil, and pre-heating coil sequentially, as shown in Figure 3. Thus the small pump and its power can be saved.

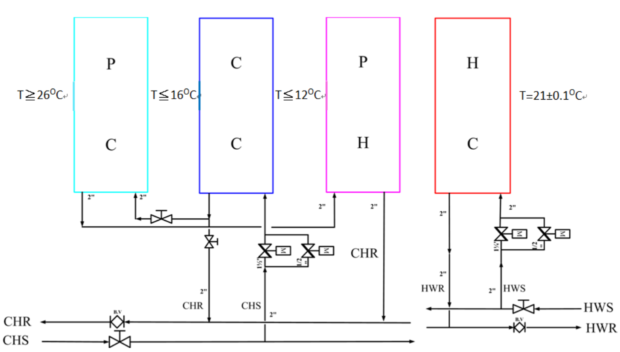

Figure 3: Modified run-around coils.

CHANGE OF POWER BILL CALCULATION MODE

There are about highly challenging 160 peak hours in one year for TPC providing electrical power. There is a hot controversy that whether we need a new nuclear power plant in Taiwan recently. The total power consumption in the 160 peak hours is a key factor. Therefore, TPC has its policy to charge the power bill.

For industrial power customers, there are two modes of power bill calculation 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. The 160 hour is in the peak hour.

NSRRC had been charged power bill according to the "two time periods" mode for years. We changed the power bill calculation mode to the "three time period" on Jan. 2012.

Due to the change of power bill calculation mode, the monthly average power bill per kW-hr of 2012 is clearly reduced compared with those of 2009 to 2011, as shown in Figurer 1.

Although this scheme does not save power, it saves much money. It saved the power bill 5,967,572 and 6,917,248 NT dollars in 2012 and 2013, respectively.

POWER COMSUMPTION CONTROL

Setting "Contract power capacity" is another crucial TPC's charge power bill policy. Contract power capacity is also 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 rules of extra charge 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 change of power bill calculation mode, the scheme of power consumption control helps TPC to plan and provide electrical 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 4 shows monthly peak power consumption in NSRRC from 2009 to 2014. Because of hot weather and power consumption of TPS construction added, the peak power consumptions of past three summers were over contract capacity. Especially in July 2010, the peak power consumption was as high as 6,200 kW. Although the conditions 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 4.

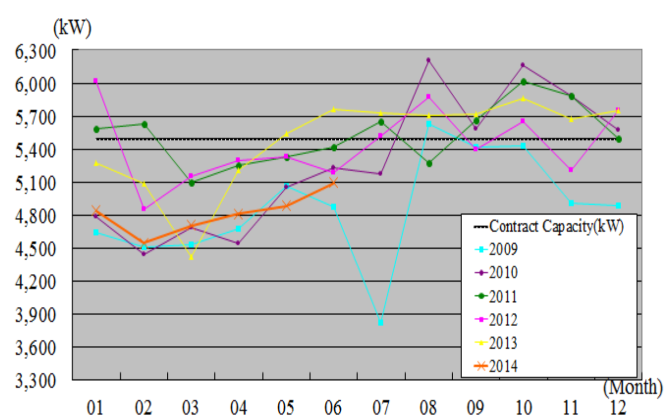

Figure 4: Monthly peak power consumption in NSRRC from 2009 to 2014.

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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 (I^2R).

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 3,033,623 dollars in 2013, as shown in Figure 5.

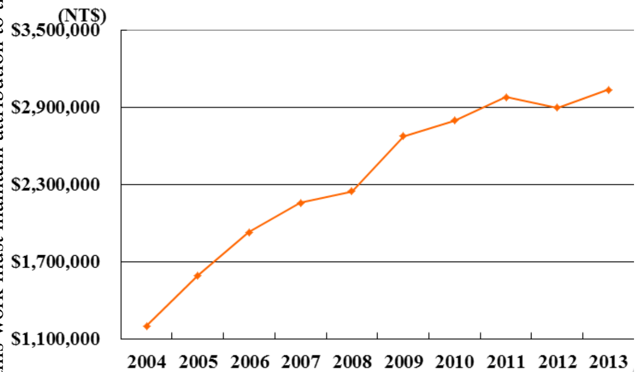

Figure 5: Power bill saved because of power factors improvement for past 10 years.

CHILLED WATER PIPES CONNECTION BETWEEN TPS AND TLS

There are three utility buildings in NSRRC. The first one was constructed for the TLS 21 years ago. There are three chillers, each with 320 RT in capacity installed inside. The second one was construction for the cryogenics and superconductivity systems 11 years ago. There are two 600 RT chillers and two 450 RT chillers installed inside. We had 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 had connected supplied and return chilled water pipes, each with 10 inch in diameter, between the second and the third Utility Buildings in 2013.

Because the chilled water may be supplied from either 2nd or 3rd Utility Building, we can also apply this scheme to control the either power consumption of TPS or TLS.

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. This committee meeting is held on May and November every year. Some action items of promotion for power saving had been assigned in the meeting. For example, 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.

Last meeting was held on May 2014. We check the reasons why the power consumption during the Chinese lunar New Year was still as high as 2,300 kW. Figure 6 shows the power consumption history during the Chinese lunar New Year of 2014. 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 committee set a target to save 30% power next Chinese lunar New Year in the meeting.

Figure 6: Power consumption history during the Chinese lunar New Year of 2014.

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.

CONCLUSION

The power saving result of those abovementioned power saving schemes is notable. Because of the TPS construction, the growth rates of power consumption of 2010 and 2011 are 3.48% and 7.26%, respectively. But the growth rates of power consumption of 2012 and 2013 are -4.5% and -2.5, respectively.

ACKNOWLEDGEMENT

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