APCBC presentation in ICEBO
(Asia Pacific Conference on Building Commissioning)
Sept. 2014, Beijing, China

Performance Evaluation of the Automatic Optimization and Degradation Detection Tool for Chiller Plants

Daisuke Sumiyoshi (Kyushu University)
Naomiki Matsushita (Aleph Networks Corporation)
Yasunori Akashi (The University of Tokyo)

INTRODUCTION

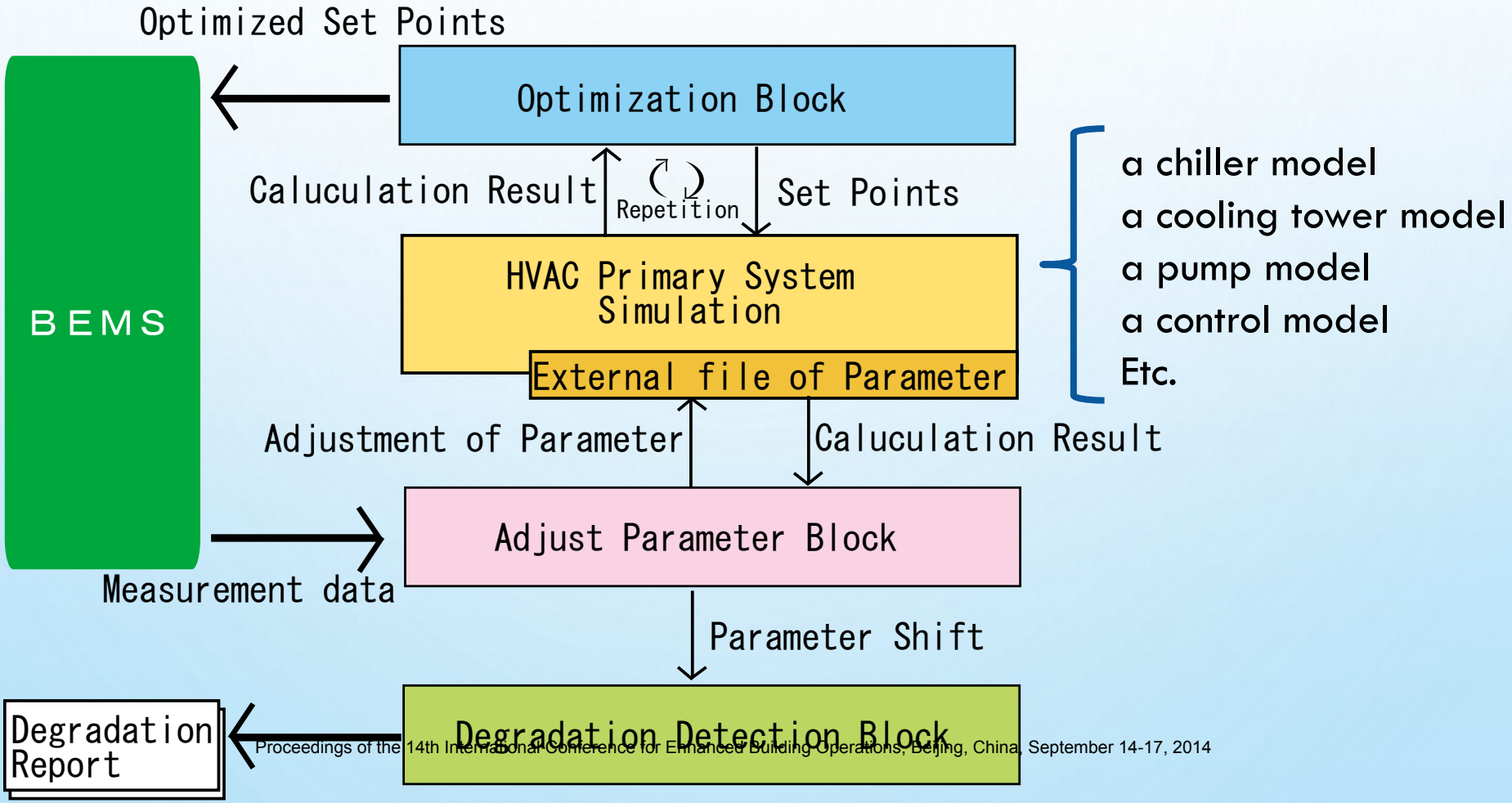
- WE DEVELOPED A TOOL **TO OPTIMIZE SET POINTS** AND **TO DETECT DEGRADATION** OF HVAC PRIMARY SYSTEM AUTOMATICALLY IN 2010.

[PURPOSE OF THIS STUDY]

- TO CLARIFY THE ENERGY SAVING EFFECT OF THIS TOOL BY MEASUREMENT FOR TWO YEARS
- TO SHOW THE POSSIBILITY OF DEGRADATION DETECTION BY THIS TOOL

THE OUTLINE OF THE DEVELOPED TOOL

- THE TOOL MAINLY HAS 2 FUNCTIONS.
  1. OPTIMIZATION OF SET POINTS
  2. ADJUSTING PARAMETER

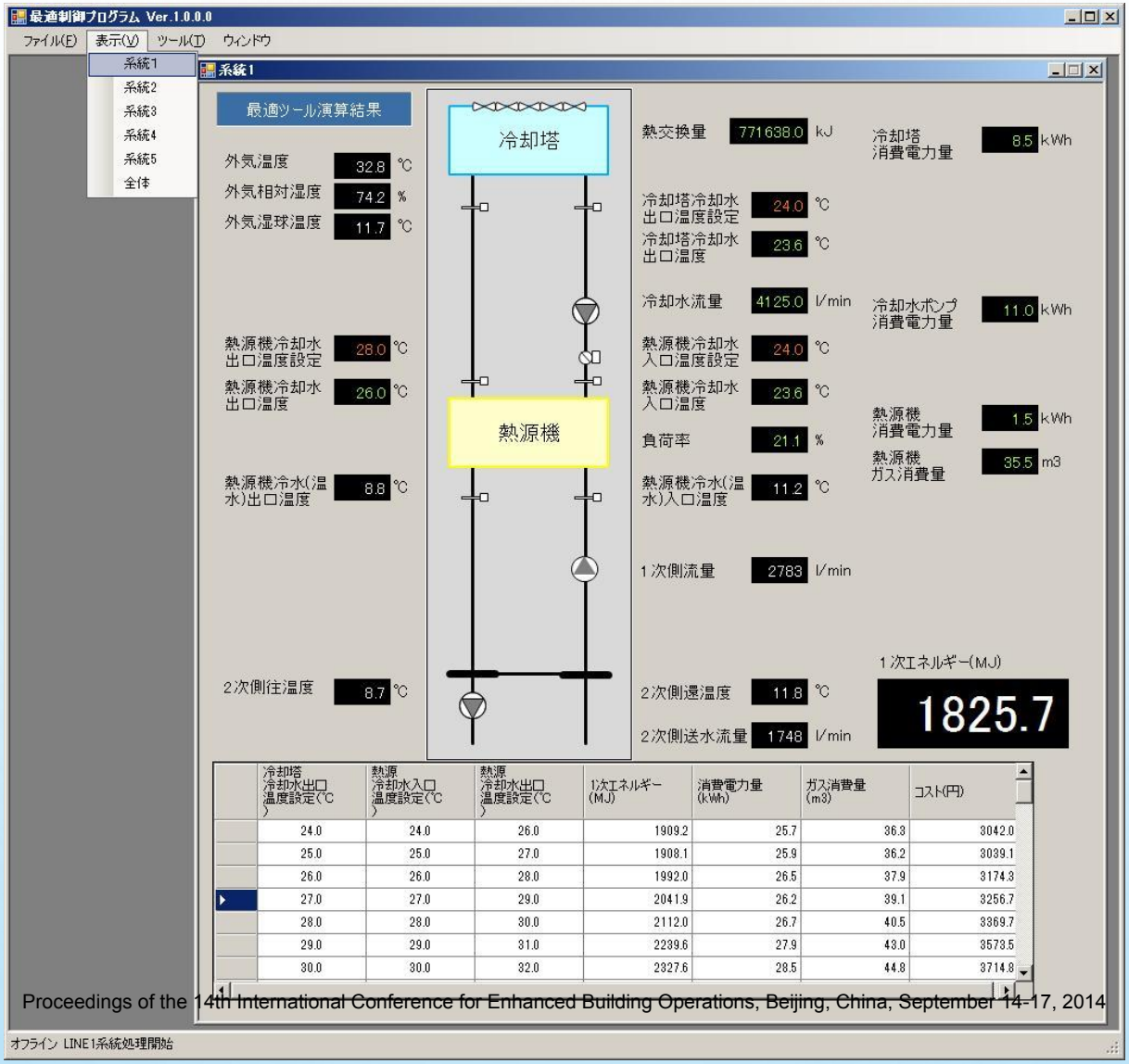


ABOUT PARAMETER

- GAS ENERGY CONSUMPTION OF CHILLER
  =PARAMETER(CHILLER, GAS)
  X （RATED GAS CONSUMPTION
  X ENERGY CONSUMPTION RATE ACCORDING TO PARTIAL LOAD RATE
  X CORRECTION BY COOLING WATER TEMPERATURE
  X CORRECTION BY CHILLED WATER TEMPERATURE ）

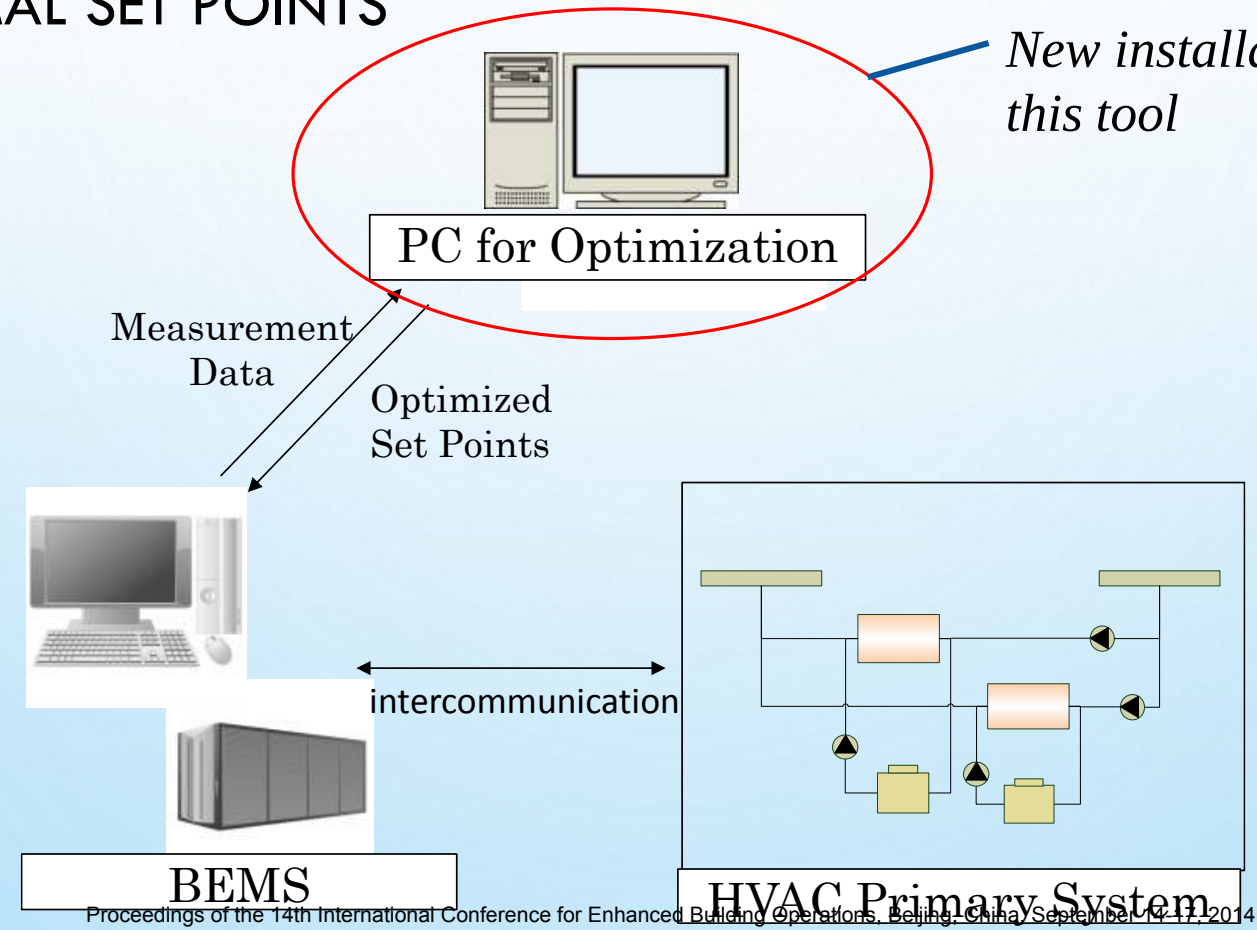
- CALCULATION RESULT IS ADJUSTED BY PARAMETER TO BE MATCHED WITH MEASUREMENT DATA
- PARAMETER IS CALCULATED BY PAST TWO WEEKS MEASUREMENT DATA.

INTERFACE OF SOFTWARE



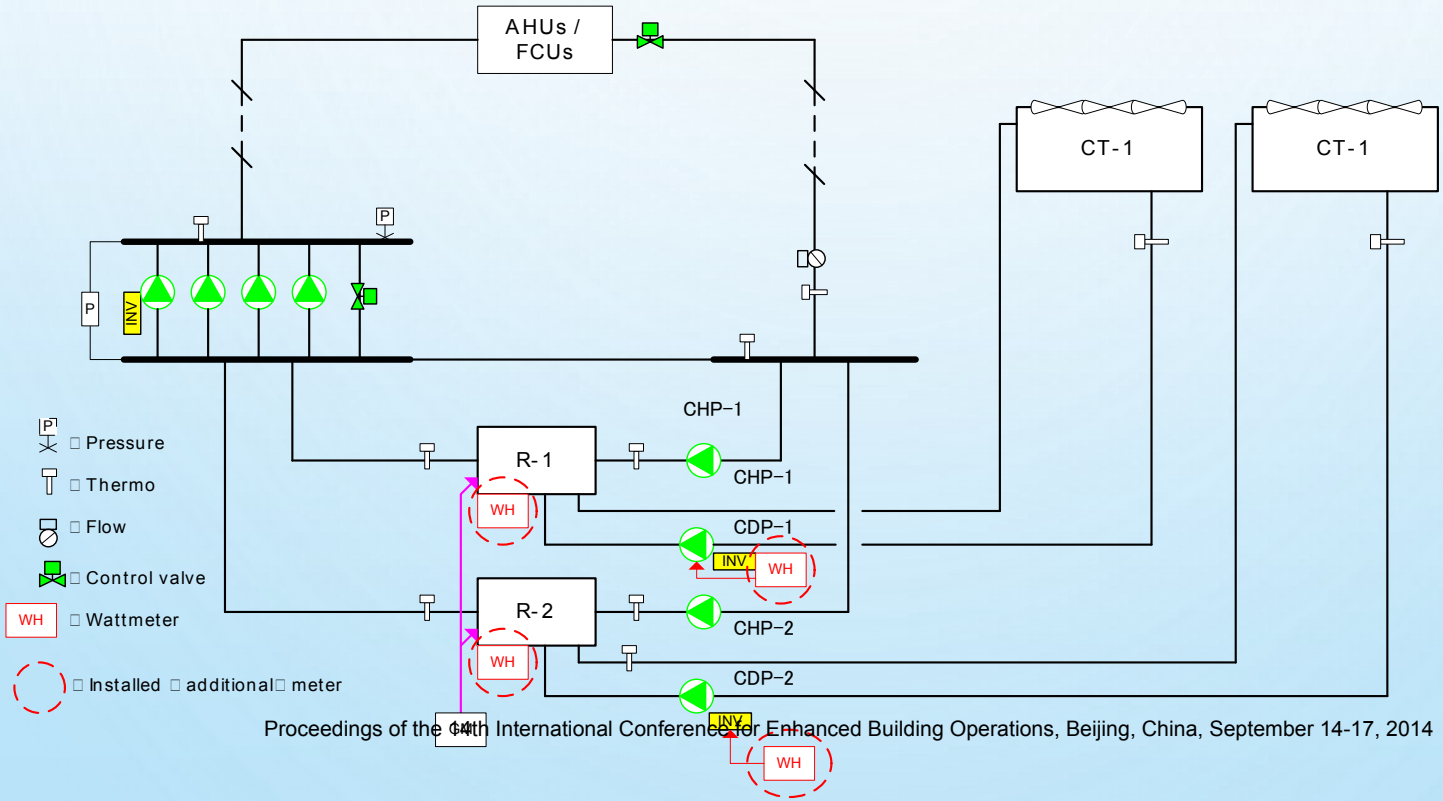
HOW TO INSTALL

- A NEW PC FOR CALCULATION BY TOOL
- REMODELING BEMS TO EXCHANGE MEASUREMENT DATA AND OPTIMAL SET POINTS



THE TARGETED HVAC PRIMARY SYSTEM FOR VERIFICATION

- THE HVAC PRIMARY SYSTEM OF A HIGH SCHOOL FACILITY IN KYOTO.
- THE PC AND ADDITIONAL ELECTRIC POWER METER WERE INSTALLED TO USE THIS TOOL, AND ALSO THE BEMS SOFTWARE WAS REMODELED.
- THE OVERALL COST FOR THE INSTALLATION WAS ABOUT ￥900,000(US$9,000).



THE EXPERIMENT CONDITION

- THE OPTIMIZATION OPERATION PERIOD, IN WHICH OUR TOOL WAS APPLIED, AND THE ORDINARY OPERATION PERIOD ALTERNATED FOR 13 DAYS FROM SEPTEMBER 2ND IN 2010.
- THE SYSTEM WAS OPERATED FOR 10 HOURS FROM 9:00 TO 19:00.
- DURING ORDINARY OPERATION, THE SYSTEM WAS OPERATED WITH FOLLOWING SET POINT;
  - THE INLET COOLING WATER TEMPERATURE :32℃
  - THE COOLING WATER TEMPERATURE DIFFERENCE :4K.

Date		Case
2-Sep	Thu	Optimization
3-Sep	Fri	Optimization
4-Sep	Sat	Optimization
5-Sep	Sun	Optimization
6-Sep	Mon	Ordinary
7-Sep	Tue	Ordinary
8-Sep	Wed	Ordinary
9-Sep	Thu	Optimization
10-Sep	Fri	Optimization
11-Sep	Sat	Optimization
12-Sep	Sun	Optimization
13-Sep	Mon	Optimization
14-Sep	Tue	Ordinary

INCREASE OF SYSTEM COP

- IT WAS OBVIOUS THAT THE HEAT SOURCE COP INCREASED BY LOWERING THE COOLING WATER TEMPERATURE DURING THE OPTIMIZATION OPERATION.
- IF THE LEVEL OF LOAD IS SAME, THE OPTIMIZATION OPERATION OF OUR TOOL ENHANCED SYSTEM COP CHANGES BY MORE THAN 10%.

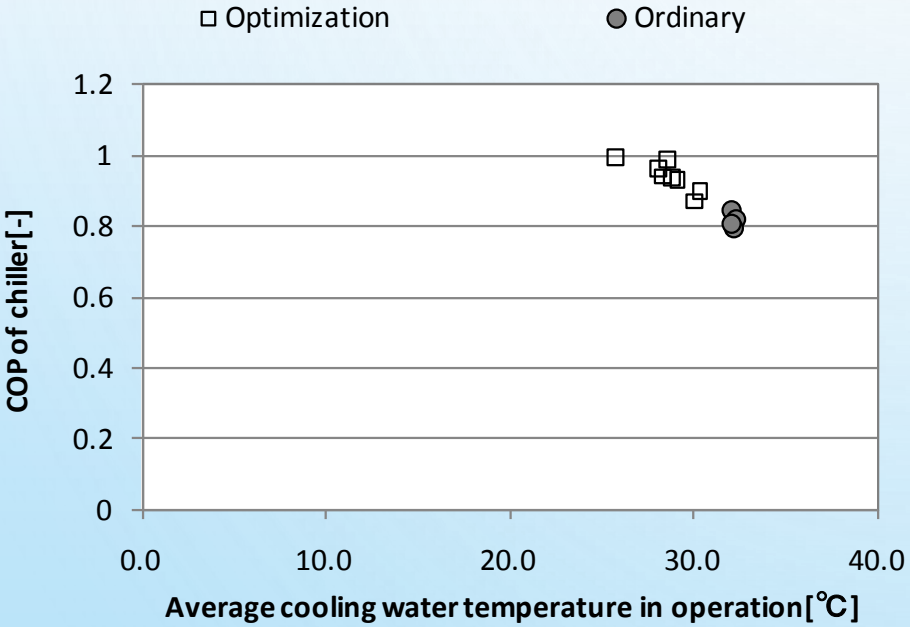


Figure 8 The relation between average cooling water temperature and COP of chiller

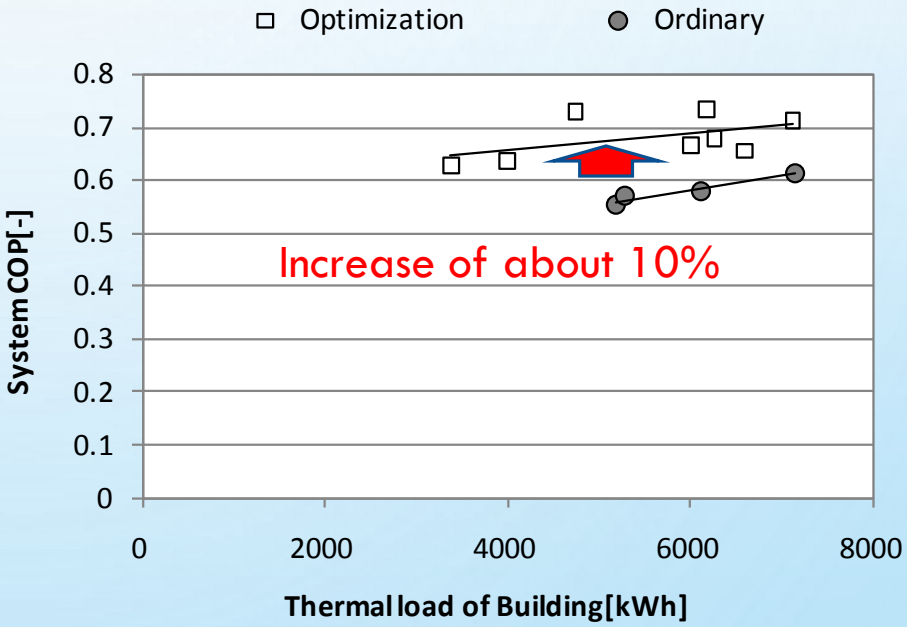


Figure 9 The relation between thermal load of the building and system COP

SELECTED SET POOINT AND MEASUREMENT VALUE

- THE SET POINT WAS 32℃ DURING ORDINARY OPERATION. THIS VALUE IS USUALLY USED IN THIS SYSTEM.
- IN THE OPTIMIZATION CASE, 24℃ IS SELECTED AS AN OPTIMAL SET POINT IN ALMOST ALL TIME ON THESE 2 DAYS. 24℃ IS A LOWER BOUND VALUE OF COOLING WATER THAT THE CHILLER ALLOWS.

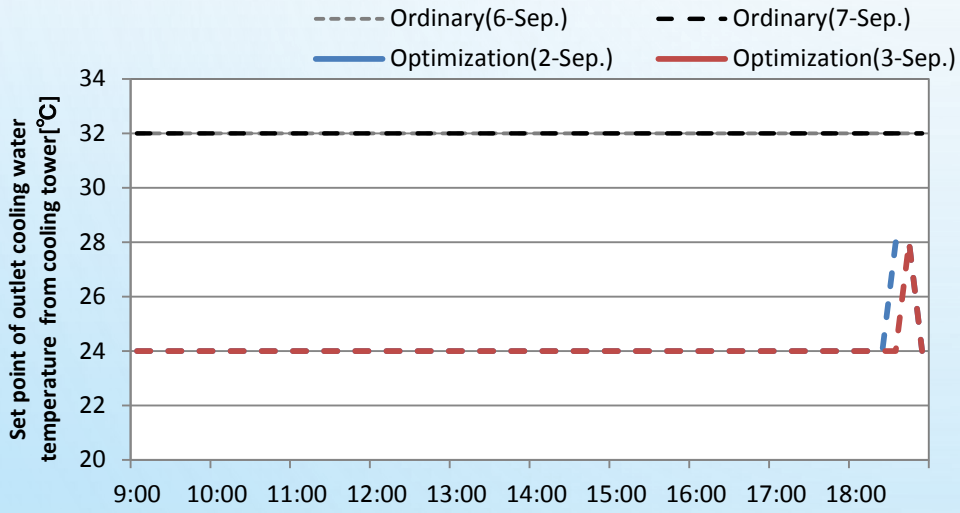


Figure 10 The comparison of set point of outlet cooling water temperature of the cooling tower

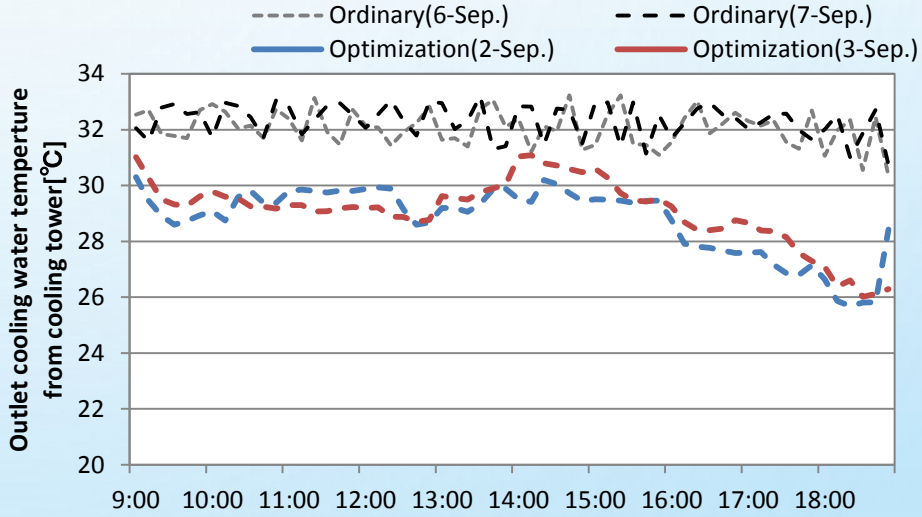
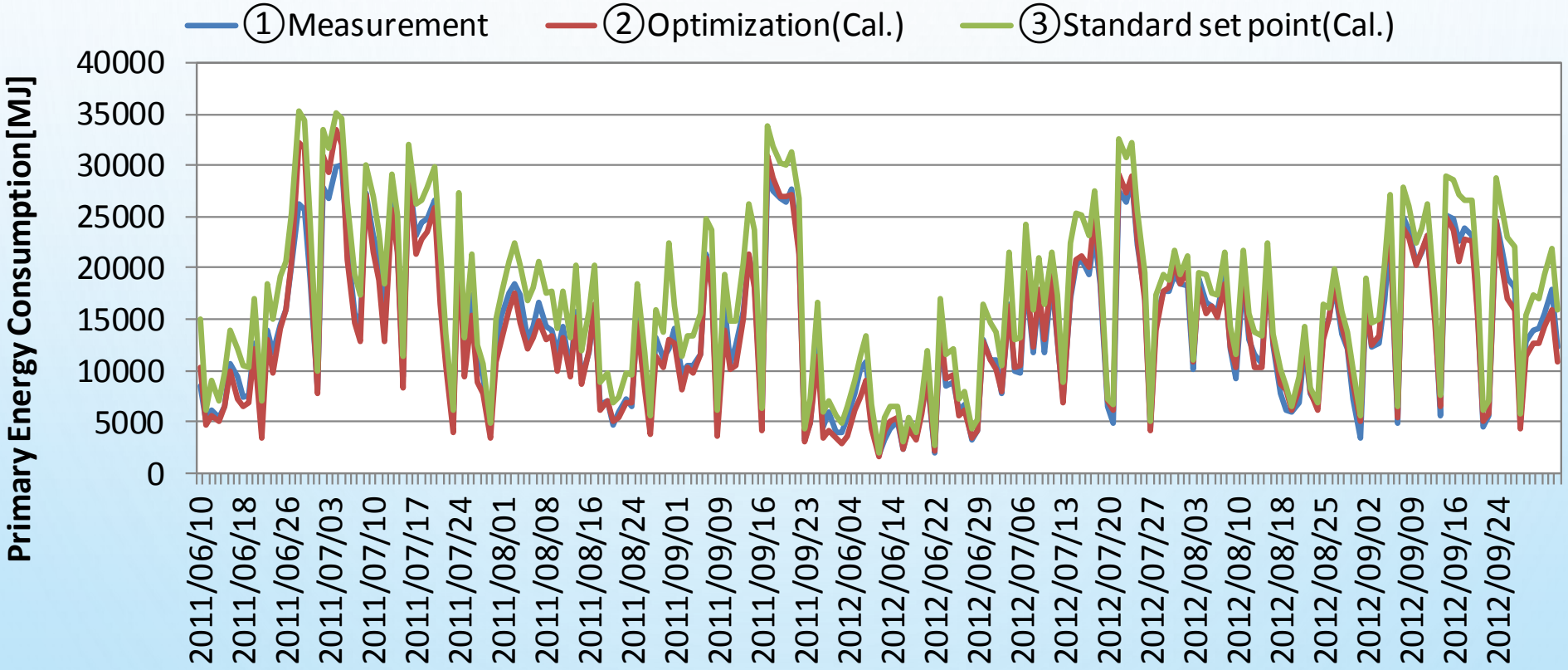


Figure 11 The comparison of real measurement of the outlet cooling water temperature of the cooling tower

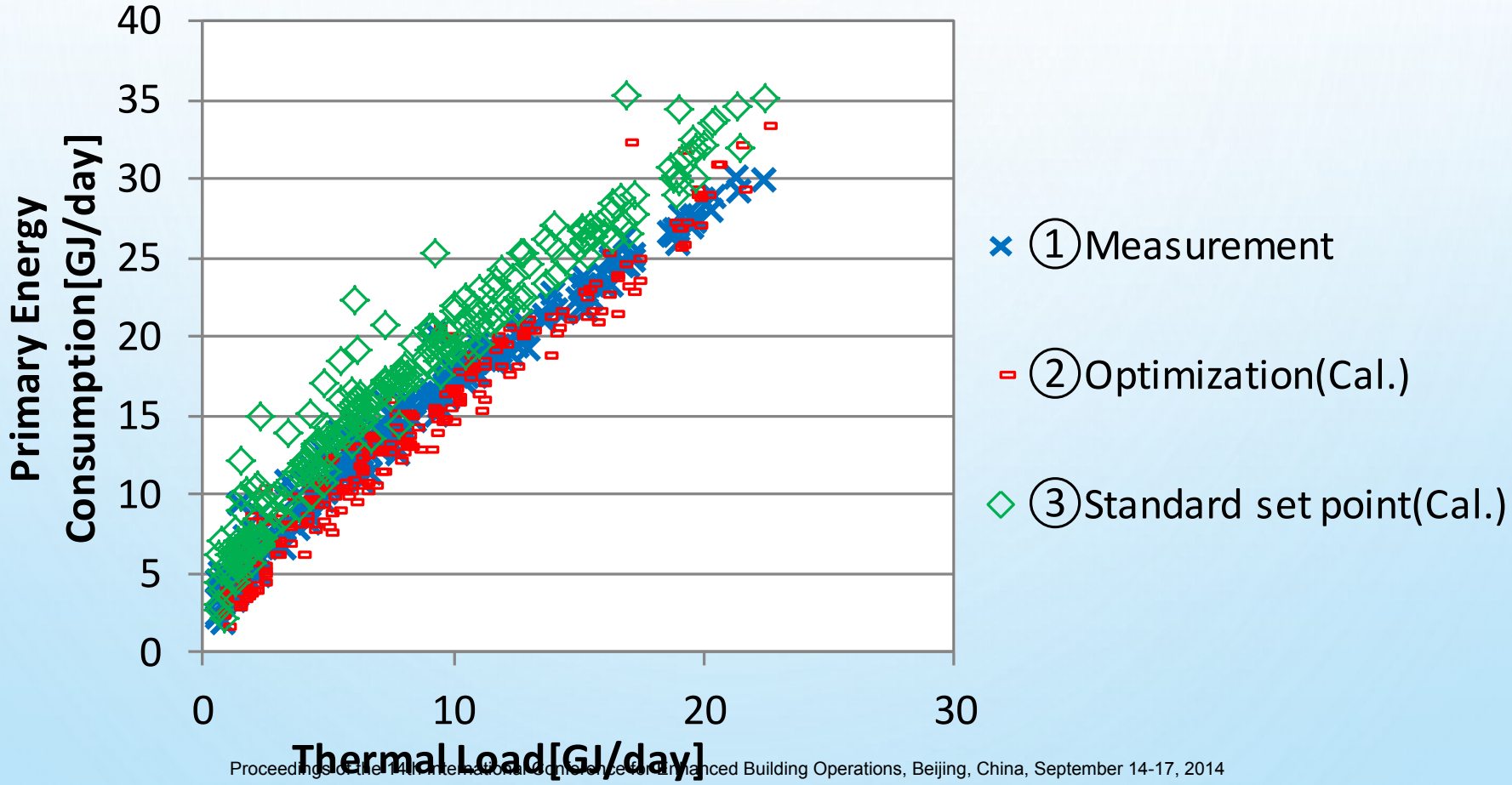
MEASUREMENT RESULT FOR TWO YEARS

- FROM 2011/JUN. TO 2012/OCT. (ONLY SUMMER)



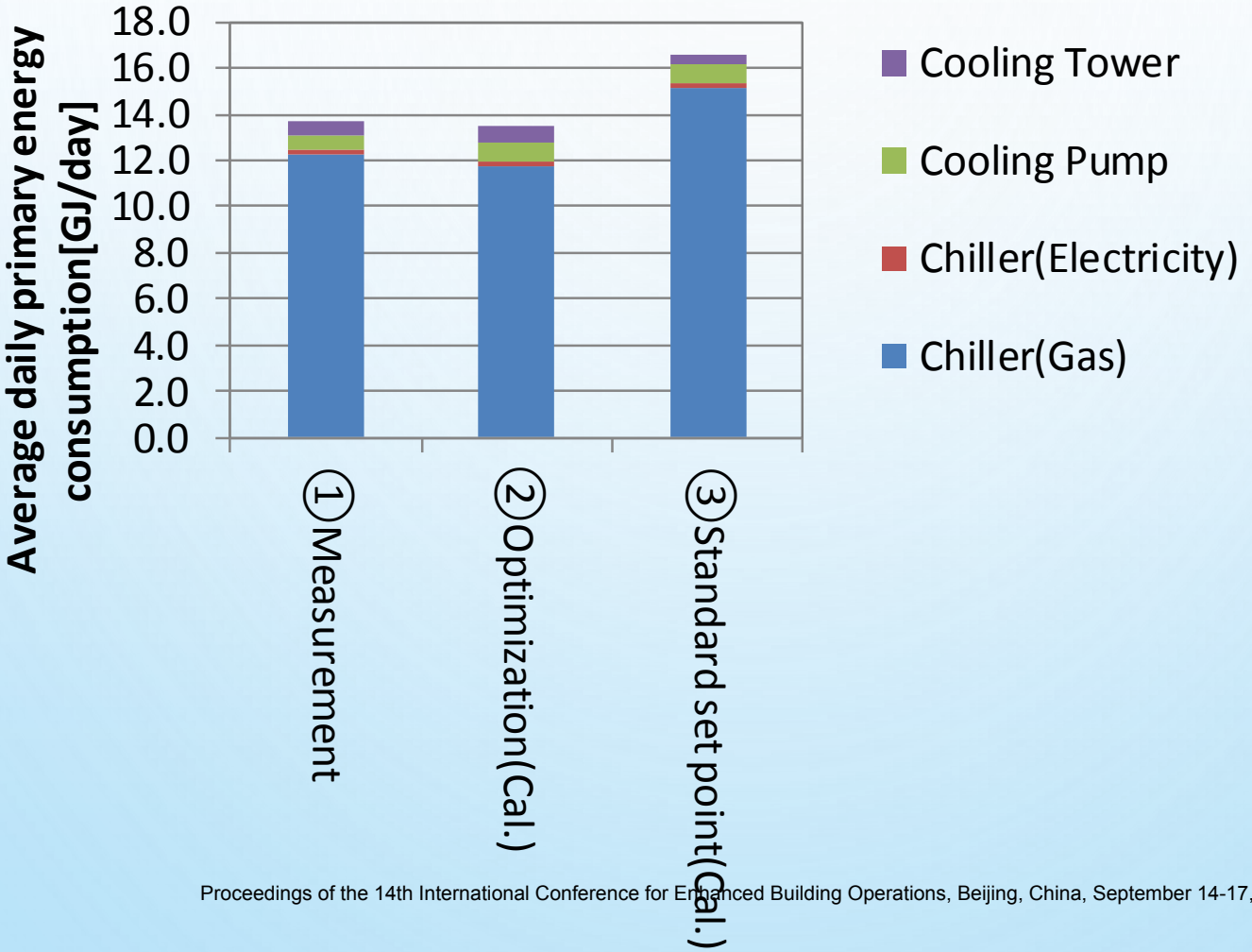
MEASUREMENT RESULT FOR TWO YEARS

- ACCURACY OF SIMULATION IS GOOD.
- THE ENERGY SAVING EFFECT IS LARGE WHEN THE LOAD IS LARGE.



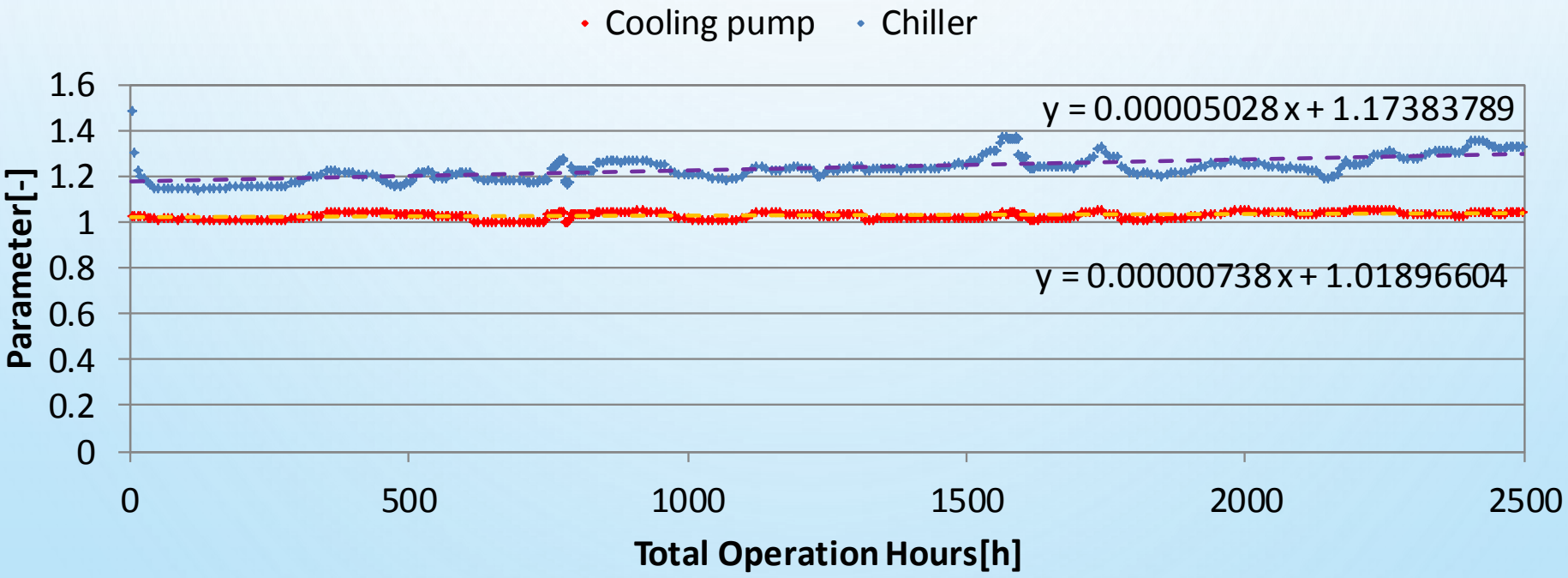
MEASUREMENT RESULT FOR TWO YEARS

- CALCULATION ERROR MARGIN IS 1.9%.
- ENERGY REDUCTION EFFECT IS 18.5%.
- THE REDUCTION COST WAS ABOUT \1,540,000($15,400) FOR TWO YEARS



POSSIBILITY OF DEGRADATION DETECTION

- THE STATUS OF DETERIORATION WAS MADE VISIBLE.
- THE DETERIORATION SPEED OF CHILLER IS 0.005 %/H
- THE DETERIORATION SPEED OF COOLING PUMP IS 0.0007 %/H



CONCLUSION

- THE OVERALL COST FOR THE INSTALLATION WAS ABOUT ￥900,000(US$9,000).
- WE CONFIRM THE EFFECT OF THIS TOOL BY SHORT TERM EXPERIMENT.
  - THE OPTIMIZATION OPERATION ENHANCED SYSTEM COP CHANGES BY MORE THAN 10%.
- IN TWO YEARS MEASUREMENT
  - CALCULATION ERROR MARGIN WAS 1.9%
  - ENERGY REDUCTION EFFECT WAS 18.5%
  - THE REDUCTION COST WAS ABOUT \1,540,000($15,400) FOR TWO YEARS
- THE STATUS OF DETERIORATION WAS MADE VISIBLE BY PARAMETER.
  - THE DETERIORATION SPEED OF CHILLER IS 0.005 %/H
  - THE DETERIORATION SPEED OF COOLING PUMP IS 0.0007 %/H

THANK YOU FOR YOUR ATTENTION!!

Daisuke Sumiyoshi
Associate Professor, Dr.Eng
Kyushu University
Faculty of Human-Environment Studies

sumiyoshi@arch.kyushu-u.ac.jp
Homepage: http://energy.arch.kyushu-u.ac.jp/