

## Facility Operations and Development Team

### 1. Team members

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### 2. Research Activities

The K computer facilities have many features not found at other supercomputer sites. These include an expansive and pillar-free computer-room, power supply system that consists of a co-generation system (CGS) and a high-speed current-limiting circuit breaker without uninterruptible power supply (UPS), distribution boards installed not on computer-room walls but under a raised floor, extremely quiet and high-efficiency air conditioners, and water-cooling system for CPUs featuring precise temperature control.

To ensure stable working of K computer and its peripherals, the facility operations and development team (FODT) of the operations and computer technologies division, RIKEN AICS is responsible for operation and enhancement of the facilities. Furthermore, FODT conducts research on the advanced management and operations of AICS' facilities.

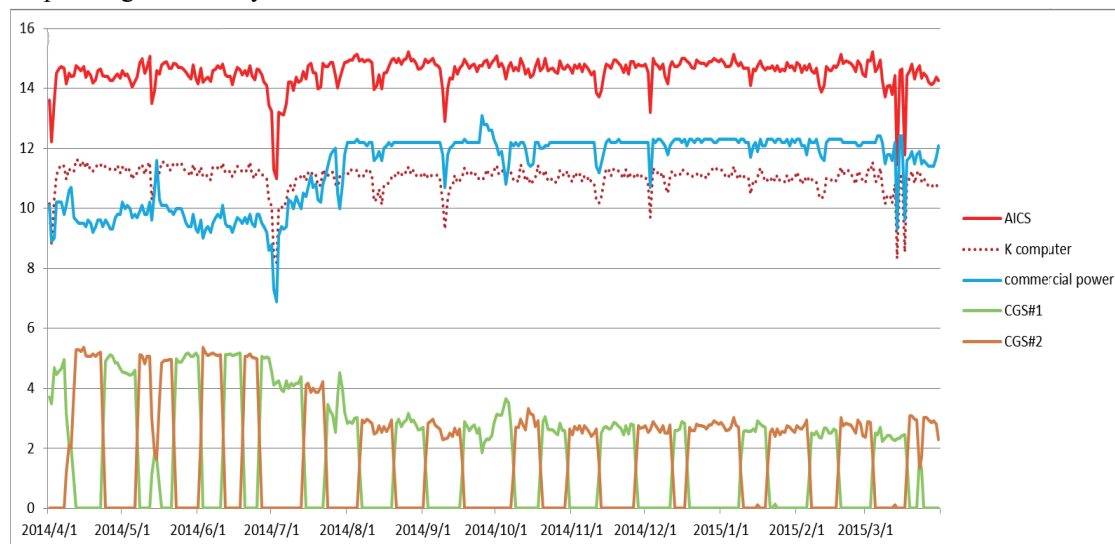
One of the most serious problems is rapid and substantial increase in electricity prices since 2011. Therefore, we investigate the most suitable driving conditions for AICS facilities to achieve effective cost reduction.

Another problem is increased power consumption by AICS. The use of electricity by AICS is strictly limited by a contract between AICS and the local electric supply company. However, recently, the facility's power consumption exceeded the contract limit. This matter is important because the company requires us to accept a raise in the upper/lower power limit, which amounts to an increase in electricity cost. To prevent this problem, we have investigated a method to control K computer's power consumption by using emergency job stopping together with the system operations and development team and the software development team of operations and computer technologies division, RIKEN AICS.

### 3. Research Results and Achievements

#### 3.1. Optimum operation of electric power

Figure 1 shows the trend in the power consumption of AICS and K computer in FY2014, and the status of power supply, which consists of commercial power purchased from a supply company and the power generated by the CGS.



**Figure 1 Trend of electric power consumption and supply (FY2014)**

The power consumption of AICS is almost synchronized with that of K computer. The power consumption of AICS is nearly 15,000 kW on average, and the power consumption of K computer accounts for approximately 80% (12,000 kW) of AICS' total consumption.

As shown in Figure 1, AICS' electric power supply consists of commercial and CGS power. There are two CGS systems in AICS, and they are used by turn for two weeks at a time. Therefore, at least one CGS is always in use. Commercial electric power is covenanted at 12,750 kW, and power consumption was approximately 12,000 kW (annual average), which corresponds to approximately 90% load factor.

To minimize the cost, we try to optimize the ratio of commercial and CGS electricity.

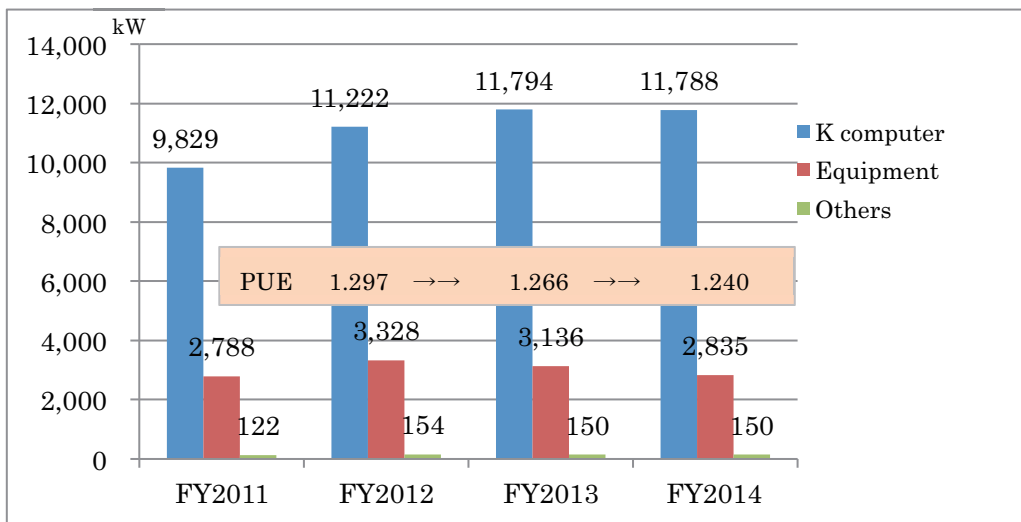
To investigate the optimized conditions that minimize the sum of electricity and gas cost, we determined the costs of several ratios of commercial electricity to CGS electricity. We also constructed a model to describe energy flow of the electric power supply and cooling system. Then, we performed computer simulation using the model and actual operating data. In FY2015, we intend to clarify the cost-optimized conditions that contribute toward reducing costs.

#### 3.2. Improvements to power usage effectiveness (PUE)

We have continued to work on improvements for the effective use of electricity. PUE is a well known indicator of the effectiveness of electricity use.

To improve PUE, we have attempted to optimize the operation of the air-conditioning system since FY2013.

Figure 2 indicates a change in the annual average power consumption of K computer (including the peripheral devices) and cooling equipment. After FY2013, the power consumption of K computer has been almost flat at approximately 11800 kW, but the power consumption of the equipment decreased gradually from FY2013 to FY2014. Accordingly, the PUE of AICS improved to 1.240 in FY2014 from 1.297 in FY2012, thus contributing to reduction in electricity cost.



**Figure 2 Trend in annual average electric power consumption**

In FY2013, we reduced the electricity cost of air-conditioners by reducing the number of working air-conditioners. Total cooling performance was maintained by lowering the air temperature. We could achieve a reduction of 192 kW in power consumption.

In FY2014, we focused on the fault-tolerance feature of the air-conditioning equipment. Each air-conditioner has two motors for fault-tolerance. We found that if one of the two motors could be stopped, airflow could be maintained at approximately 60%. Thus, we reduced power consumption by a further 301 kW.

#### 4. Schedule and Future Plan

We will continue to improve the advanced management and operation of AICS facilities and contribute to the user service of K computer. We will work on reducing costs by investigating and applying the most suitable driving condition to all of the electric power supply and cooling equipment. Furthermore, we will improve electric power control of the entire AICS facility to prevent overshooting the contracted power demand with the system operations and development team.

## 5. Publication, Presentation, and Deliverables

### (1) Journal Papers

1. Keiji Yamamoto, Atsuya Uno, Katsufumi Sugeta, Toshiyuki Tsukamoto, Fumiyoshi Shoji, “スーパーコンピュータ「京」の運用状況,” IPSJ Magazine Vo.55 No.8 pp.786-793, 2014. (In Japanese)

### (2) Conference Papers

1. Atsuya Uno, Hajime Hida, Fumio Inoue, Naoki Ikeda, Toshiyuki Tsukamoto, Fumichika Sueyasu, Satoshi Matsushita, Fumiyoshi Shoji, “Operation of the K computer Focusing on System Power Consumption,” HPCS2015, 2015, Japan. (In Japanese) (to appear)
2. Lili Jin, Kouji Yutani, Hiroyuki Yamano, Hiroyuki Takitsuka, Satoshi Matsushita, Toshiyuki Tsukamoto, “計算科学研究機構における設備最適運転条件の検討その2,” Proceedings of the 49<sup>th</sup> Japanese Joint Conference on Air-conditioning and Refrigeration(Tokyo). (In Japanese)
3. Satoshi Matsushita, Hiroyuki Takitsuka, Toshiyuki Tsukamoto, “スーパーコンピュータ施設における低騒音空調機の省エネ運用,” Proceedings of the 49<sup>th</sup> Japanese Joint Conference on Air-conditioning and Refrigeration(Tokyo). (In Japanese)

### (3) Invited Talks

- None

### (4) Posters and presentations

1. Fumio Inoue, Atsuya Uno, Toshiyuki Tsukamoto, Satoshi Matsushita, Fumichika Sueyasu, Naoki Ikeda, Hajime Hida, Fumiyoshi Shoji, “電力消費量の上限を考慮した「京」の運用,” IPSJ-SIGHPC 2014-HPC-146 No.4, 2014. (In Japanese)
2. Atsuya Uno, Hajime Hida, Naoki Ikeda, Fumio Inoue, Toshiyuki Tsukamoto, Fumichika Sueyasu, Fumiyoshi Shoji, “「京」におけるジョブ単位の消費電力推定の検討,” IPSJ-SIGHPC 2014-HPC-147 No.20, 2014. (In Japanese)

### (5) Patents and Deliverables

- None