A Heat Re-Use System for the Cray XE6 and Future Systems at PDC, KTH

Gert Svensson, PDC, KTH, Stockholm, Sweden

Johan Söderberg, Hifab, Stockholm, Sweden

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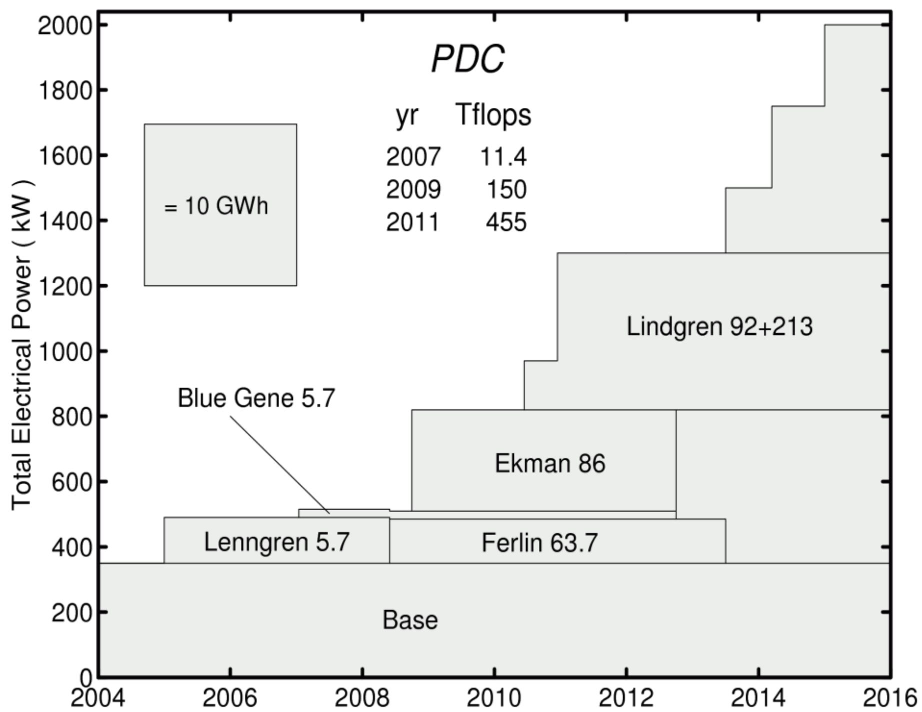
Overview

- Background
- Preliminary investigations
- Final solution
- Experiences
- Savings
- Future development
- Questions

Background

- 800 kW power
- District cooling
- Power cost 0.10 €/kWh
- Cooling cost 0.06 €/kWh
- 1,100,000 €/year
- Cray XE6 +500 kW



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Idea heat re-use for the Cray

- Do something better for the Cray
- Be more environmentally friendly
- Save some money
- Save district cooling (0.06 €/kWh)
- Save district heating (0.06 €/kWh)

Project group

- KTH
- Akademiska hus
- Sweco
- Incoord
- Hifab

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Different temperature levels

- Current cooling (CRAC, APC HACS) 18 °C
  - Too low to heat buildings
- Cray Liquid cooling option in the same range

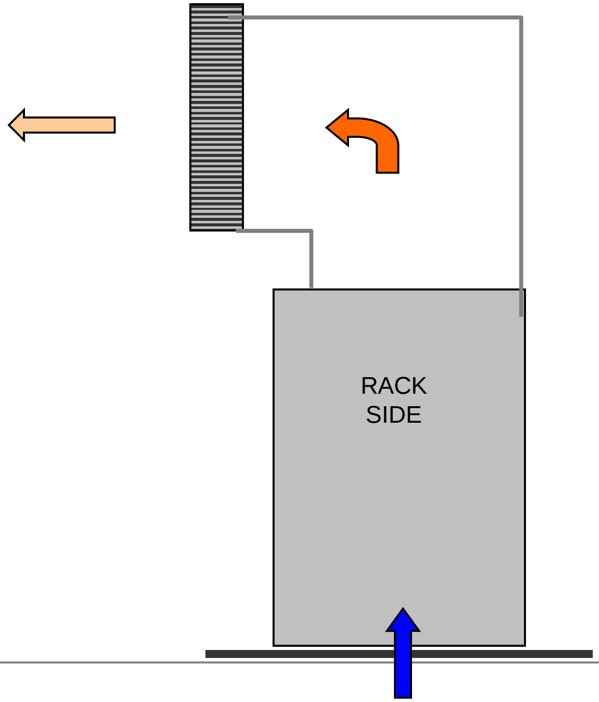
- To heat incoming air around 25-30 °C is required
- To heat existing radiators around 40-50 °C is required
- Cray XE6 air cooled takes in < 16 °C in raised floor and exhausts around 35-40 °C on the top
- So usable temperatures exist to heat incoming air to a building

How to collect the hot air

- Industrial heat exchangers can convert hot air to water without loosing to much temperature
- Problem: they are big, heavy and contains water
- Size of the room implied two rows of Cray racks
- So how to place the heat exchangers?
  - Between the racks => problem with cables
  - At the end of the rows => not enough space
  - On top of the racks => risk for water in Cray
- Additional fans not required

Collecting the air

- Final solution: Over the racks but displaced so not directly over the Cray



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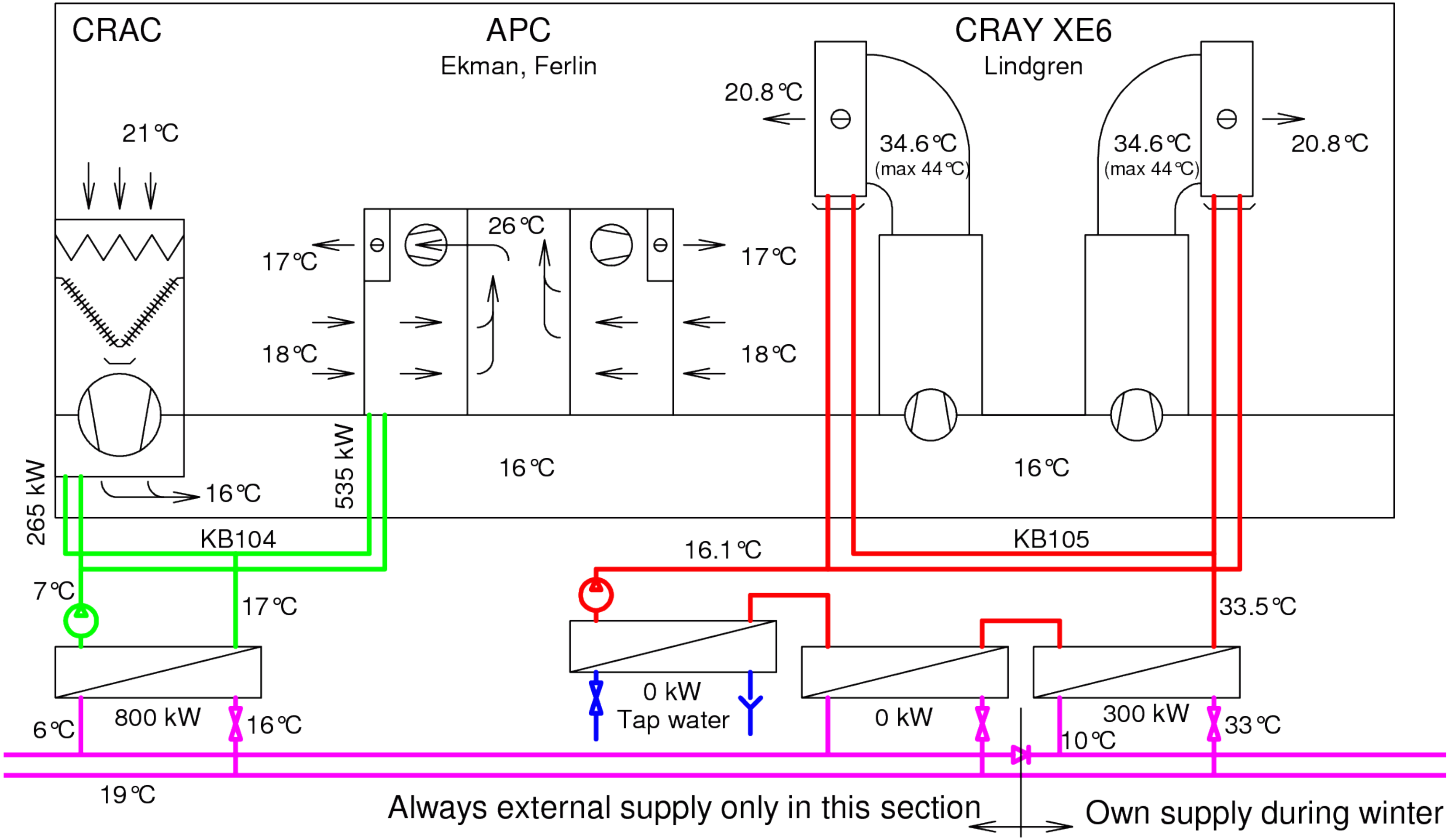
Infrastructure at the center



Selection of building to heat

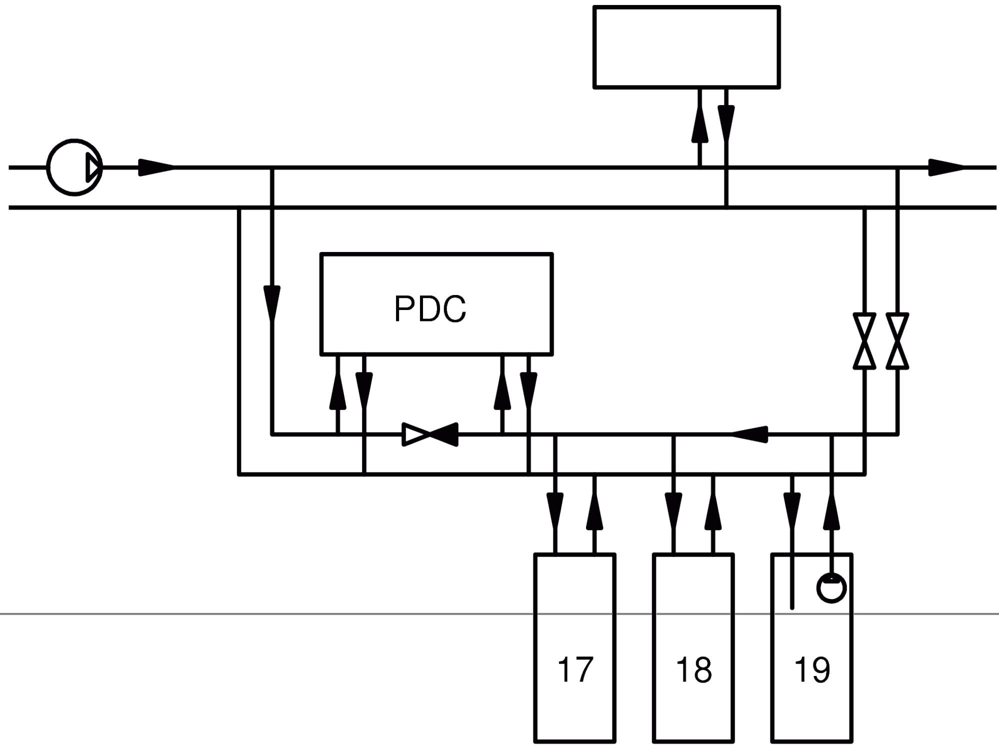
- Chemistry building was good candidate
- Was undergoing renovation
- Using larger than usual amount of air to ventilate fumes from the labs
- Only heat from offices was recovered

Transporting the heat to the recipient

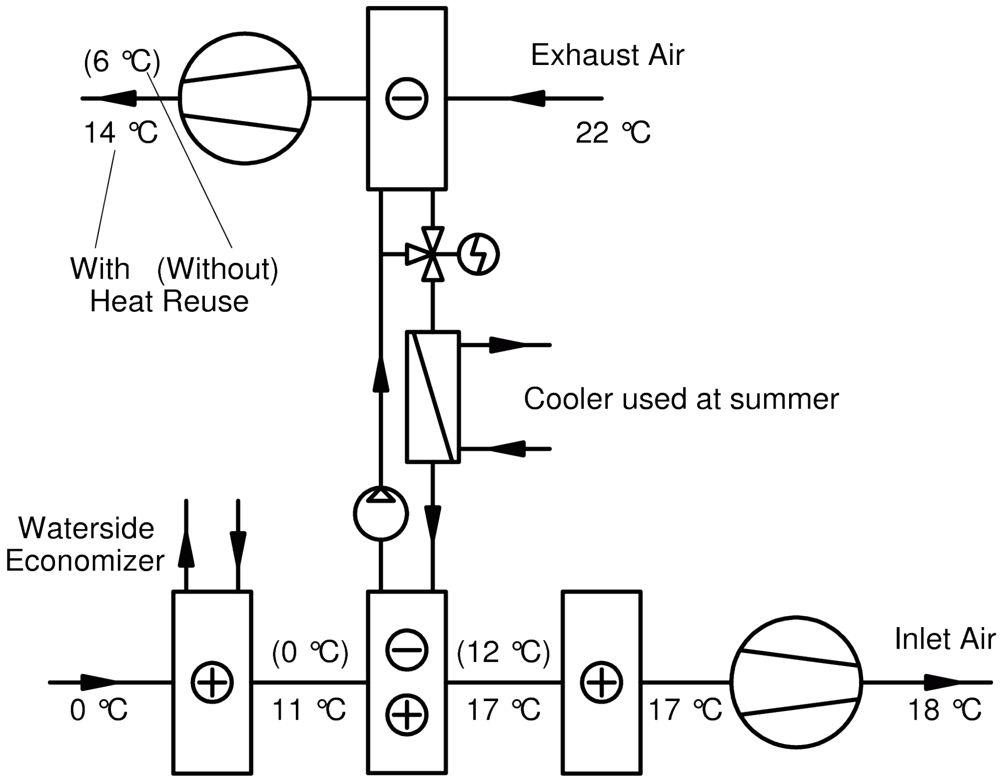
- Laying down now pipes to expensive
- Existing ring network for district cooling around KTH
- Idea: cut off the part between the center and the recipient building and reverse the flow in that part

Use of the district cooling network

- Problem: district cooling users on that part of the network
- Solution: Keep the return temperature so low it can be used for cooling (< 10 °C)



In the Chemistry building



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Experience of the project

- Computer world vs. construction world
  - Different time scales
  - Ordering and installation of a super computer much faster than preparing the infrastructure
  - A computer installation last 3-4 years
  - Building installations may last 30 years
- Getting correct information for custom solution
  - Cray most helpful to provide information
  - We visited the Cray installation in Finland to check
  - Still some small details of the Cray had changed

Overall function

- Many initial adjustments
- After that very stable
- Not a single cooling interruption
- Heat re-use continued to work during district cooling failure
- Efficiency almost as predicted
- But many possible optimizations

Cost savings

Cray power 500 kW

-10 % not captured (power supply etc).

-30 % air cooled by CRAC (from 22 °C to 16 °C)

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300 kW sent to the Chemistry building

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Cost savings cont'd

In operation 50 % of the year

District cooling saving:

300*24*365*0.5 = 1.3 MWh/year a 0.06€ => 80 k€

Chemistry building already has heat re-use of 50 % => additional heat only saves 50 %

District heating saving:

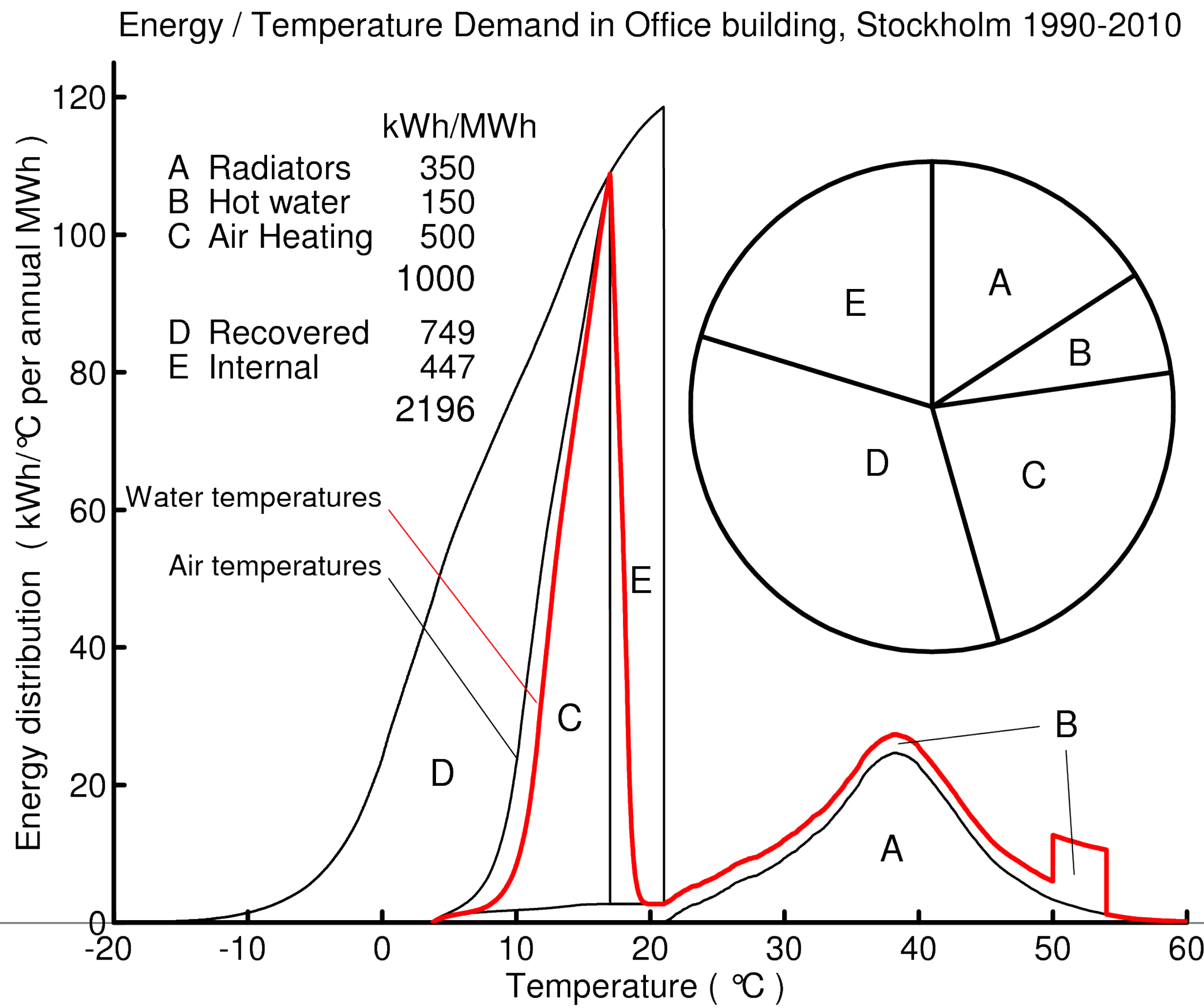
150*24*365*0.5 = 0.66 MWh/year a 0.06€ => 40 k€

Total saving: 120 k€/year

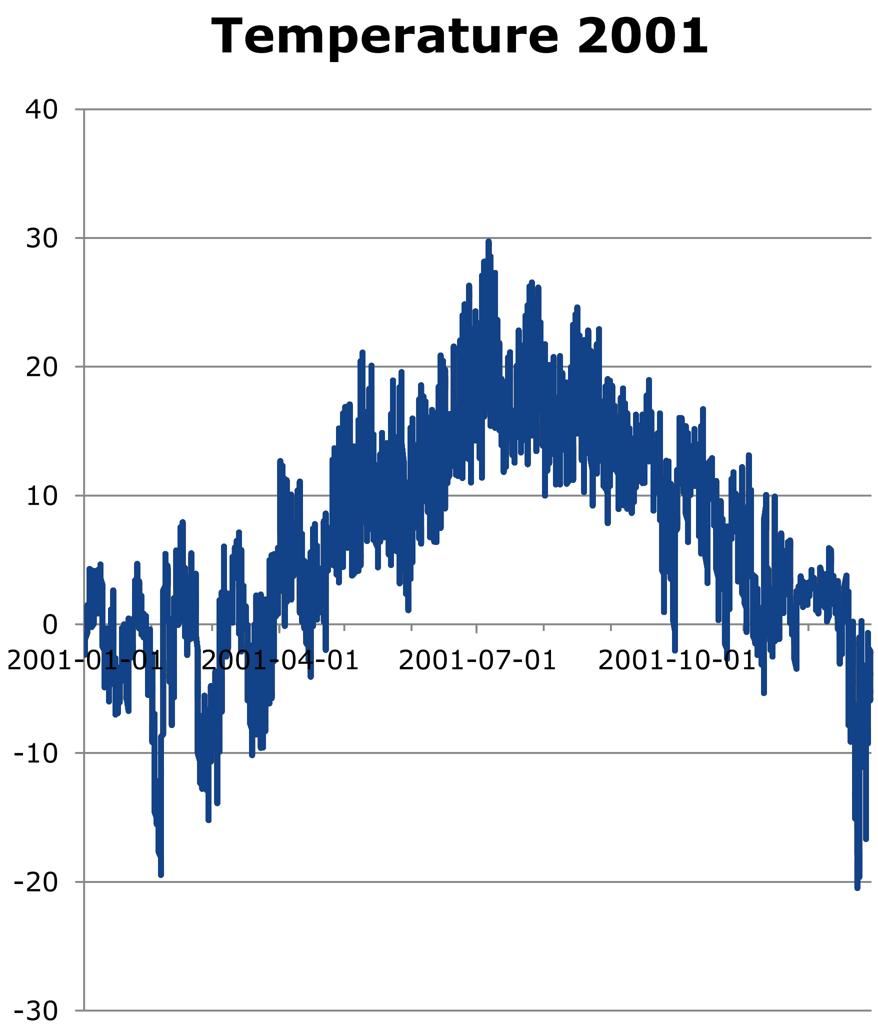
Future development

- Different classes of cooling technology
  - Low temperature CRAC, APC etc. (20 °C)
  - Medium like this Cray cooling (30-35 °C)
  - High temperature, direct water, submerged oil or direct evaporative cooling (50 ° C)
- Different classes of heat re-use
  - Pre heat ventilation air
  - Floor heating
  - Radiator heating

Energy distribution in an office building

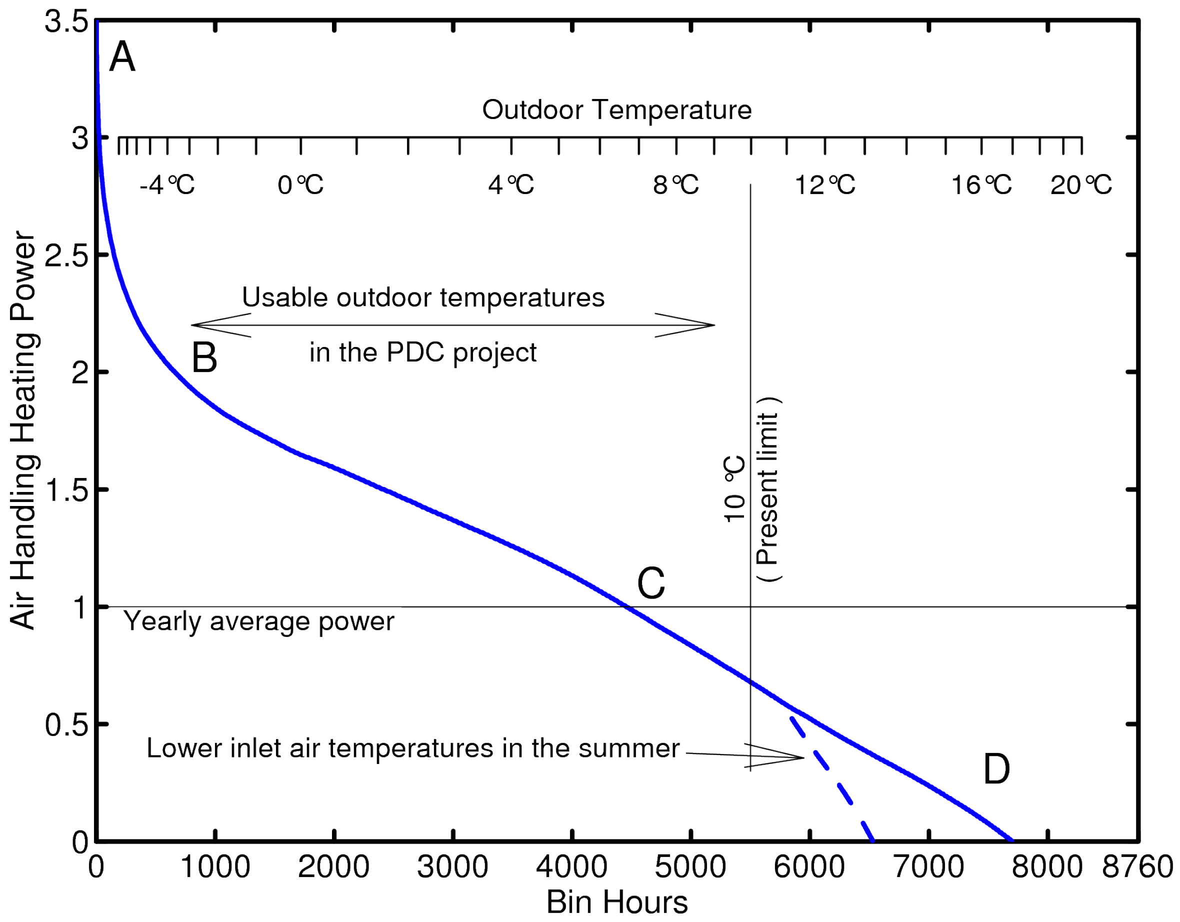


Climate considerations

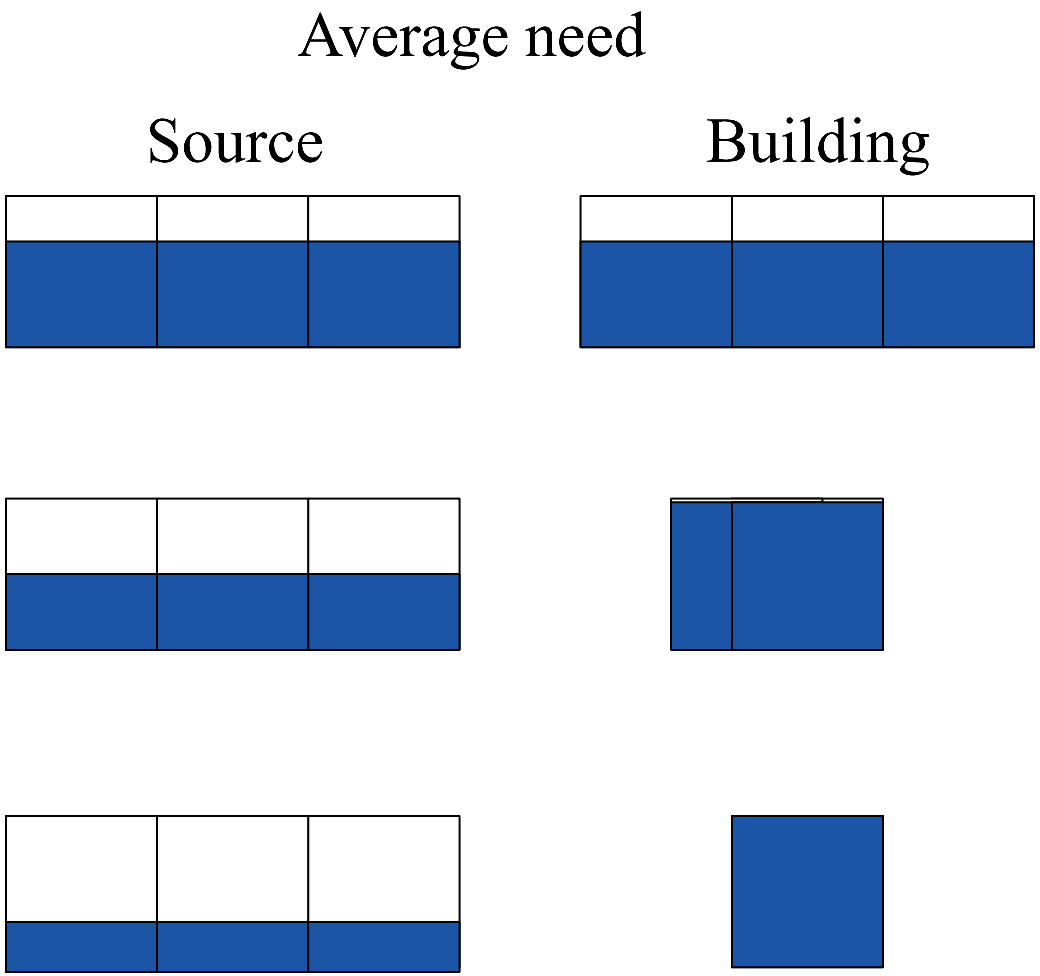


- No heating is required during 3 months
- The coldest day requires 4 times the average heating
- The Cray can produce 2-2.5 times the average heat demand of the Chemistry building

How often is additional power needed?



How much area can we heat?

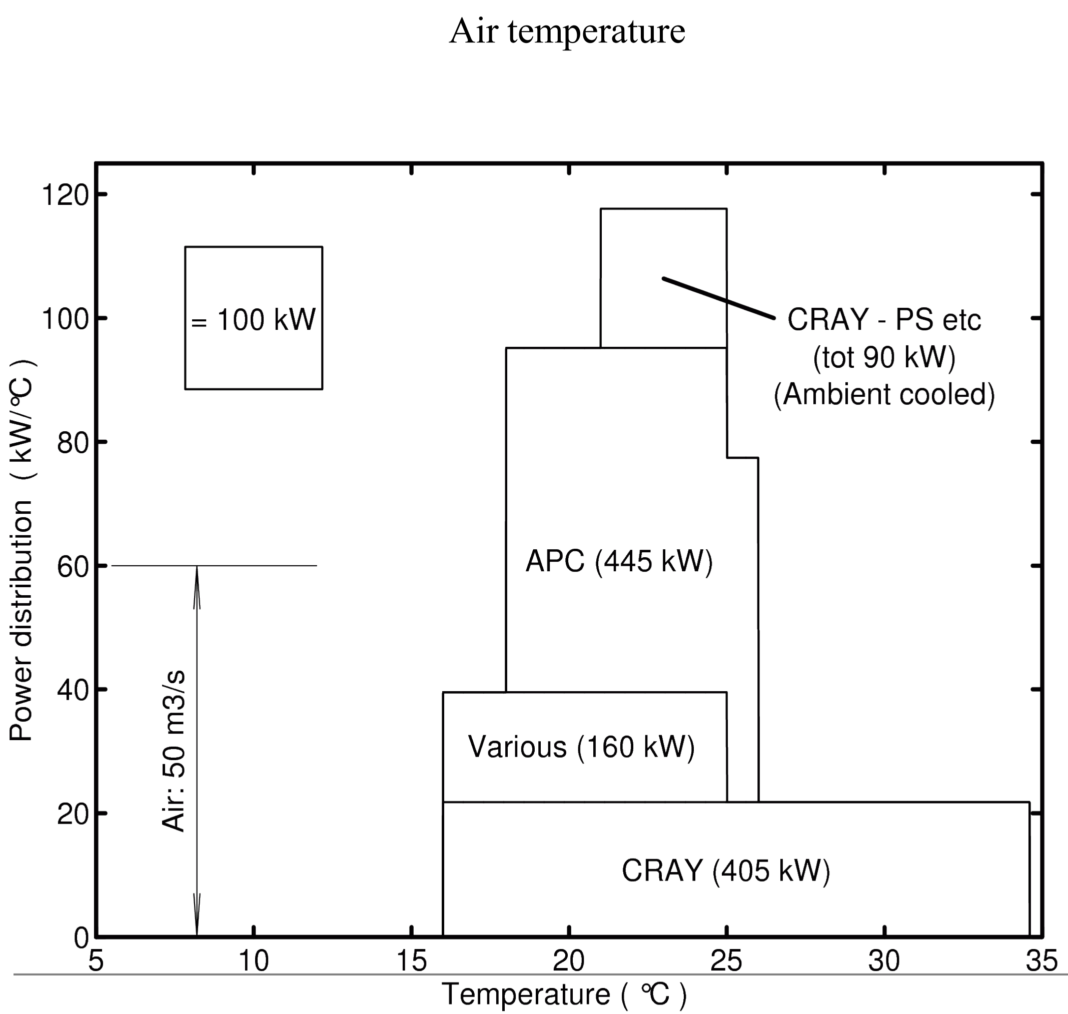


70 % of re-covered energy used
70 % of the energy required in the building covered by re-use

50 % of re-covered energy used
97 % of the energy required in the building covered by re-use

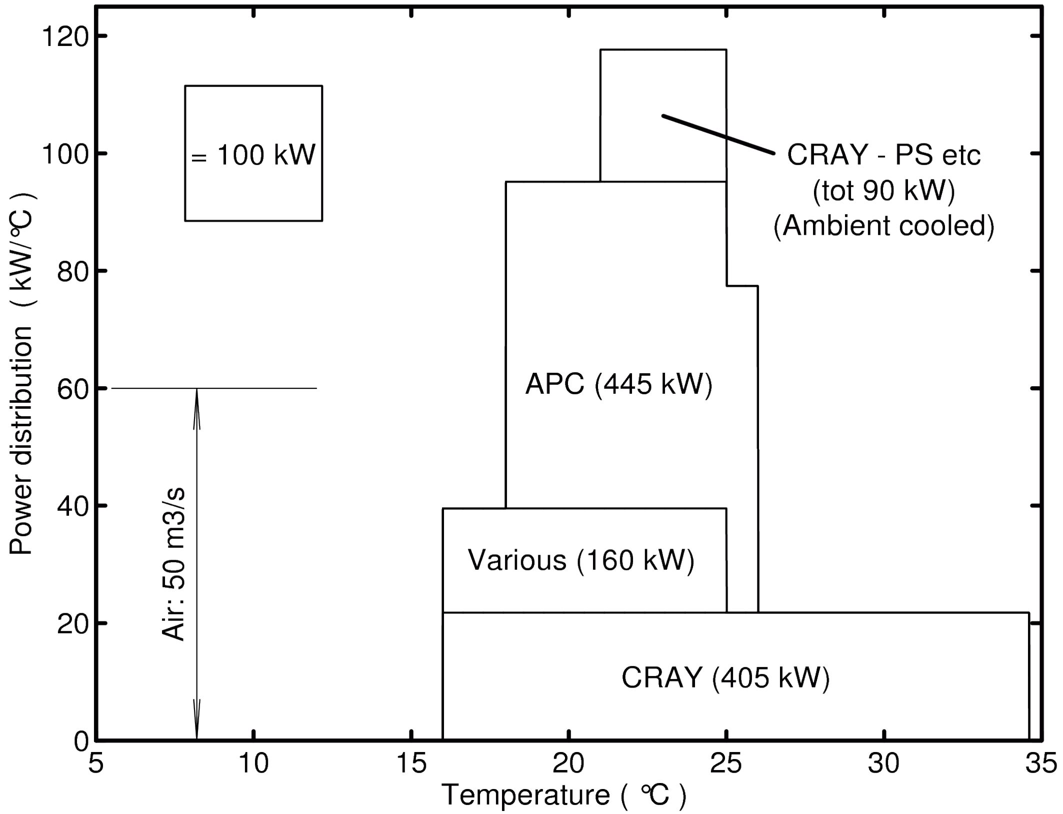
33 % of re-covered energy used
99 % of the energy required in the building covered by re-use

A way of describing power and temperature

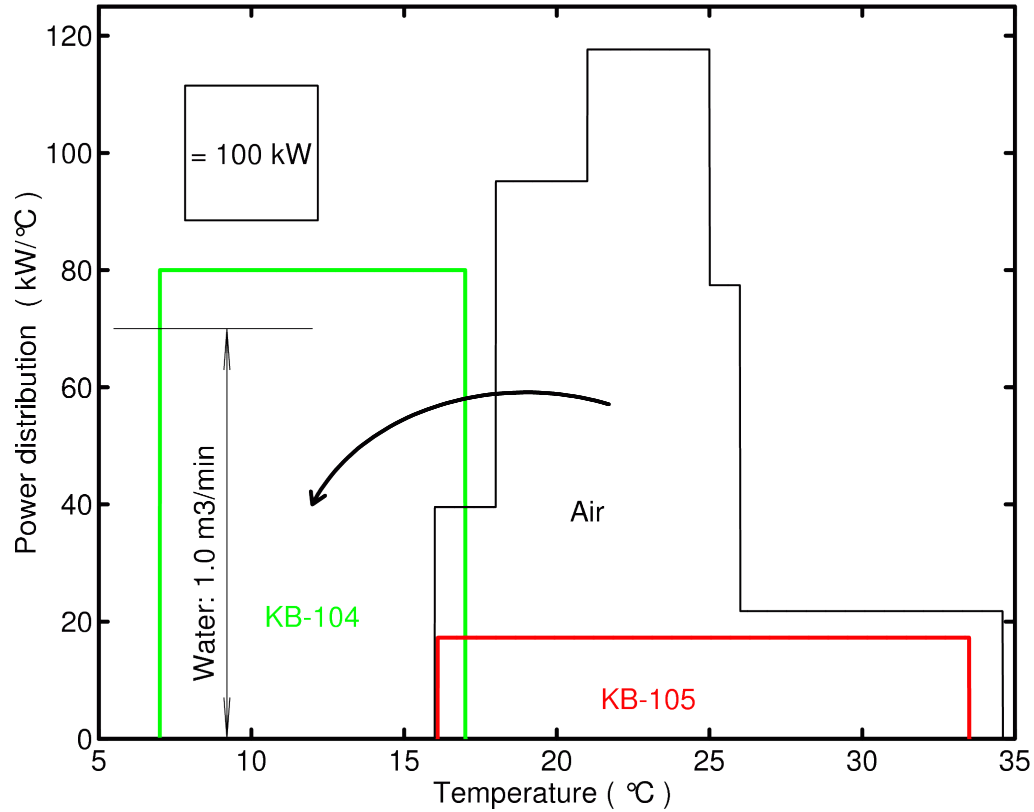


A way of describing power and temperature

Air temperature



Water temperature



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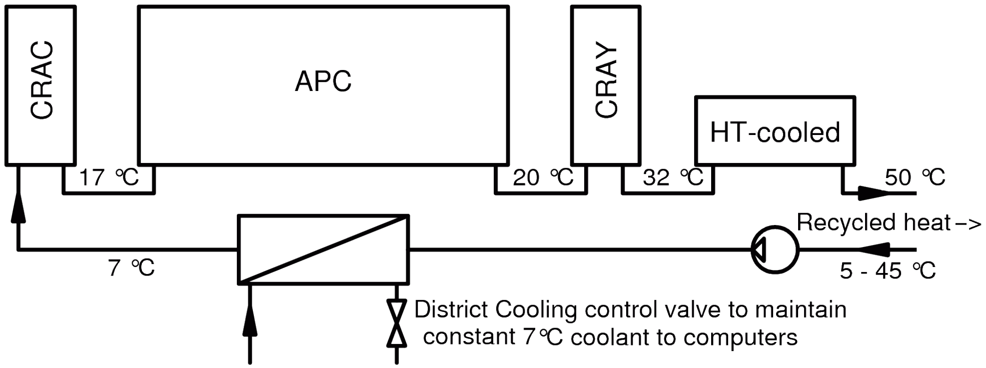
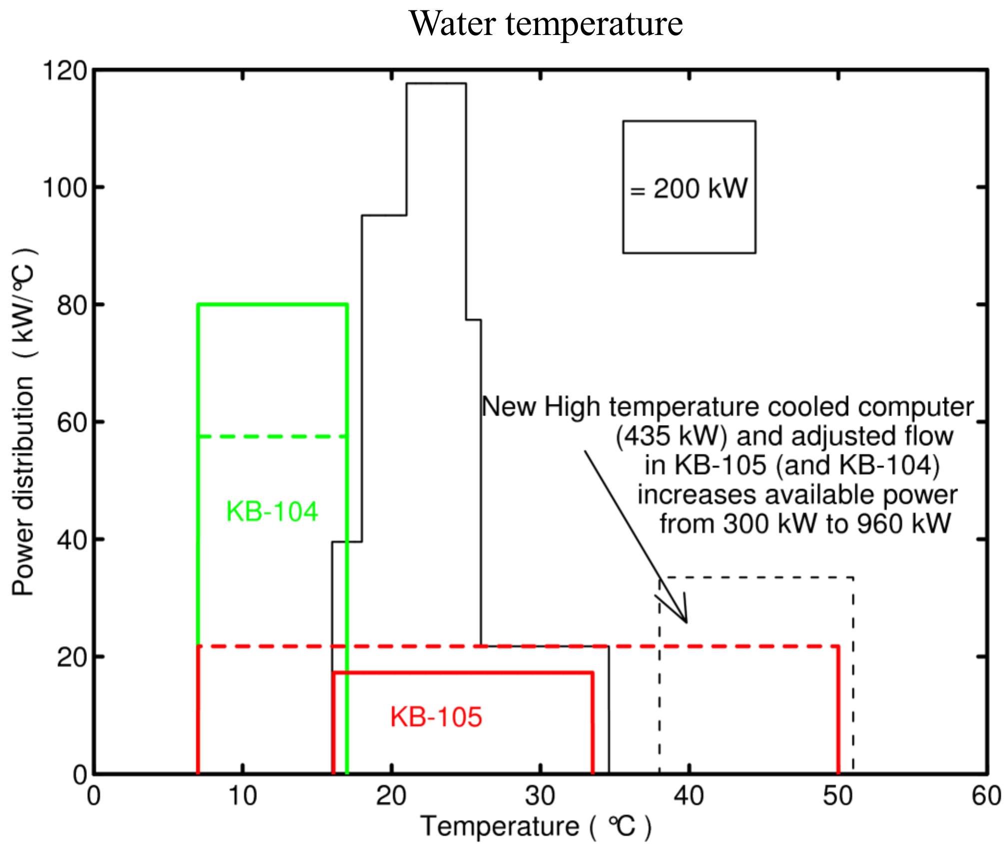
Several computers in a chain





Conclusions

- We have shown that heat re-use is possible with an air cooled supercomputer
- Collect heat close to the source
- Use large heat exchangers not to loose temperature
- Low temperature losses all they way is important
- No new pipes or heat pumps needed
- Possible to extend for other for future systems with other temperature characteristics

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Questions ?