Energy Efficient Data Centre at Imperial College

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Contents

- Recognising the Wider Issue
- Role of IT / Actions at Imperial
- Data Centre Actions based on Burton Group recommendations
- Data Centre at Imperial
- CO_2 Cooling / How does it work?
- Nearly three years in operation – Reliability / Issues
- Analysis of Efficiency
- Conclusion

Recognising the Wider Issue – College Wide Initiatives

- An active approach through a College-wide programme
- Upgrade heating plants and insulate heating pipe-work – halves the amount of CO_2 released
- Centralise individual A/C units using more efficient absorption chillers
- Phased introduction of 10% voltage reduction – 500 tonnes of CO_2 each year
- Metering of power across the campus improved
- Energy from renewable resources - warm and cool water boreholes
- Focusing on recycling
- Food miles, further paper waste, reuse building rubble, transport policies, ecology, etc.

Imperial College London is a world leading science-based university whose reputation for excellence in teaching and research attracts students (11,000) and staff (6,000) of the highest international quality.

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Role of IT – What has been done so far?

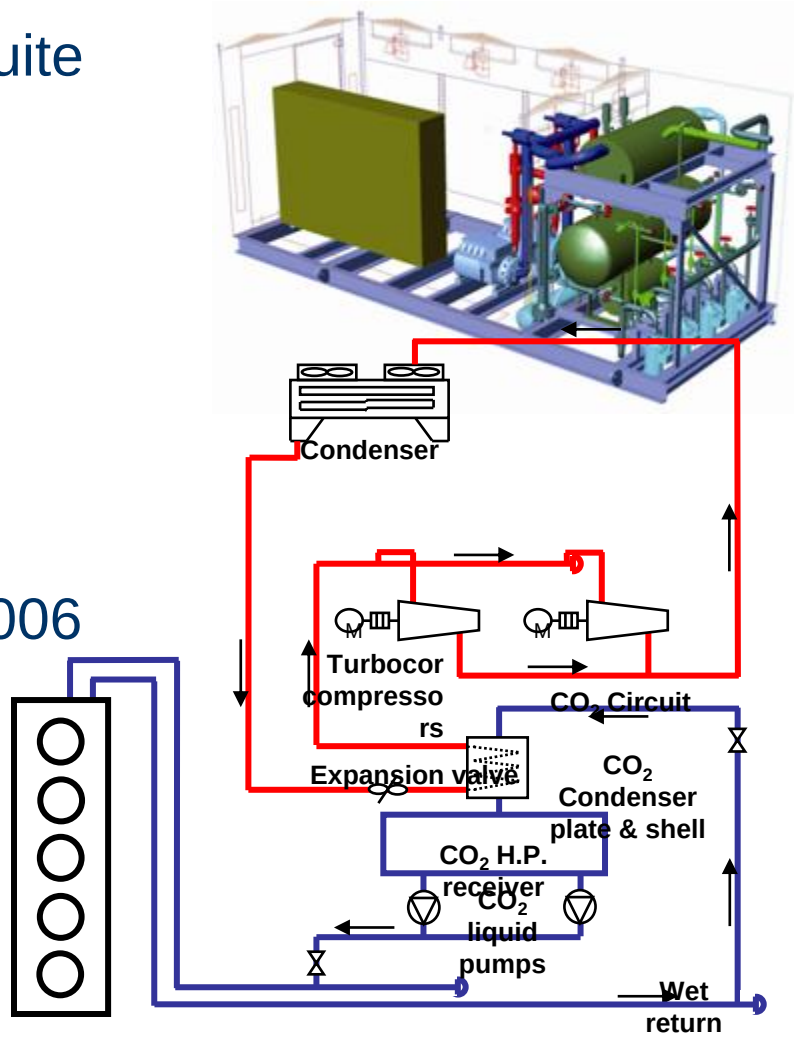
- Use of LCD monitors / CRT replacement initiative
- Power saving activated on PCs
- Recycling of PCs
- Remote Working
  - Provision of voice / tele-conferencing
  - Increased management support for home working
  - OCS infrastructure made available for on-line conferencing
- Distributed unified printing facility
  - Number of desktop printers reduced
  - Managed idle power-off enhances savings
- New network edge switches most efficient in its category
- New equipment comply with green policy guidelines of the College
- Data Centre initiatives
  - Centralised hosting of group servers

Burton Group Recommendations for Data Centres

1. Employ high-density options: blade servers, virtualisation
   - 500 blades for HPC, plus 40 for Business Systems so far
   - Virtualisation policy: virtual clients by default
2. Consolidate storage space
   - College SAN in place for seven years
   - Storage virtualisation
3. Energy-efficient hardware such as multi-core CPUs
   - Standard server hardware
4. Hot aisle/Cold aisle layout
   - New Data Centre implemented this way
   - Recently, also implemented boxed cold aisle
5. Use Liquid Cooling
   - Efficient, because cooling activity is localised and enclosed
   - Volume of CO_2 to move around is much less

New Data Centre in 2006

- HEFCE funding for a new e-Science Suite
- For High- Density / Performance computers
- Obvious candidate – liquid cooling
- Implemented between 2004 and 2006
- CO_2 Mission Critical Cooling
  - Designed/tested in Summer 2005
  - Installed in Oct - Dec 2005
  - Server occupation April – August 2006
- Basic characteristics:
  - 300kW Roof mounted air cooled condenser
  - 15 x 20kW rack mounted Coolers



Designed for 1 MW server capacity, 750 square meters, 30x CO_2 + 150x standard cabinets
Also included standard water cooled chillers at 2x520 kW capacity using efficient screw compressors – running in active/passive mode

CO_2 Cooling Units

***BLADE* POPULATED RACKS**

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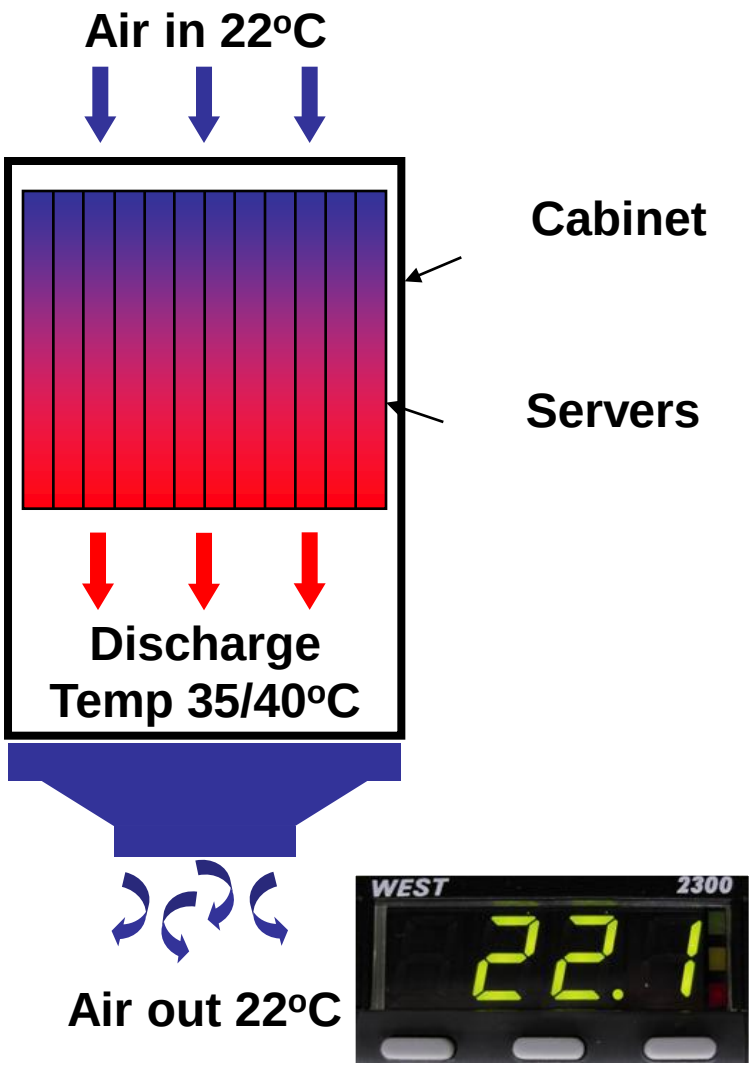
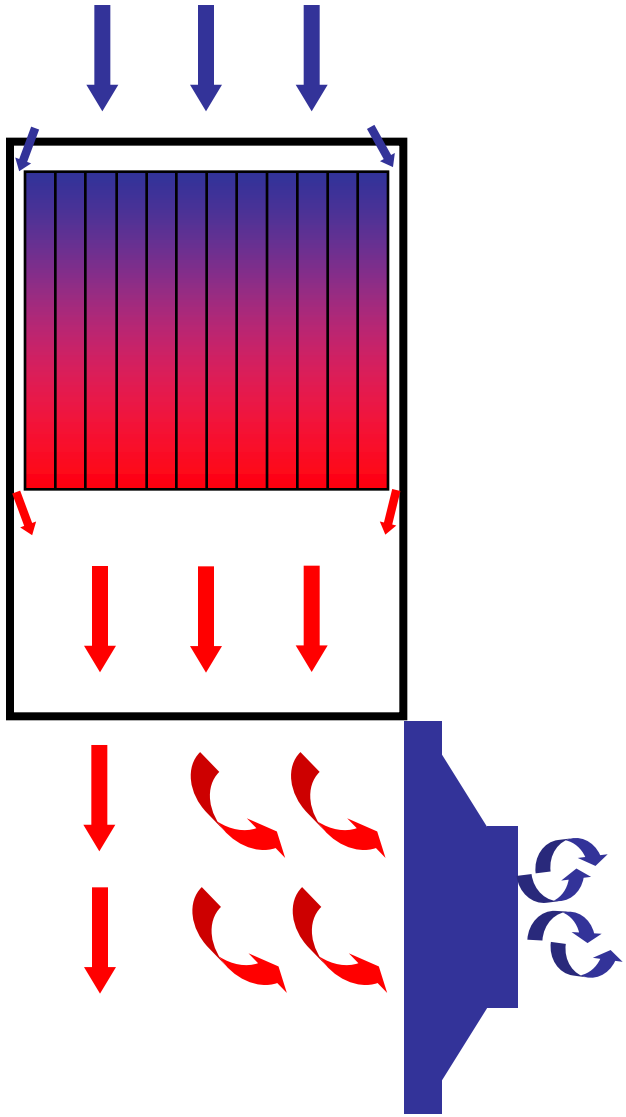
CO_2 Racks Design Basis

- Closed system
  - CO_2 circulating at 14°C
  - Above dew point: no condensation
- Air drawn into cabinets by ‘blade’ fans
- Inlet temperature ambient
- Server air discharge temperature 35/40°C
- Discharged air drawn through cooler
- Heat load absorbed in heat exchanger by partial vaporisation of liquid CO_2
- Air discharge temperature ambient
- Controlled access
  - 3-speed fans; N+1
  - Fan ‘Hot swap’
  - UPS back-up for the fans
  - Off rack temperature display
- Various displays, indicators, alarms
  - Fan failure, CO_2 discharge, BMS connection



CO_2 Cabinet Access

- Access via rear hinged door
- Server load discharged
  - ~ 60/70% into Cooler: load absorbed
  - ~ 30/40% into aisle



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Nearly three years in operation – Reliability / Issues

- Remote monitoring by TROX used to detect and resolve issues
  - One of the four pumps was replaced without disrupting the service (N+1)
- London plane trees “dusting” the cooler inlets with their seeds and causing a shutdown
  - Regularly being combed out during allergy season
- One major failure causing abrupt increase of ambient temp.
  - Fans continued keeping air flowing
- A couple of door leaks over three years
  - Detected through the drop of internal CO_2 pressure – not serious enough to trigger the CO_2 alarm
  - Racks isolated and doors fixed without disruption to the rest of the system

“The system has proved extremely reliable and support from Star has been good.”
Steve Lawlor, Data Centre Manager

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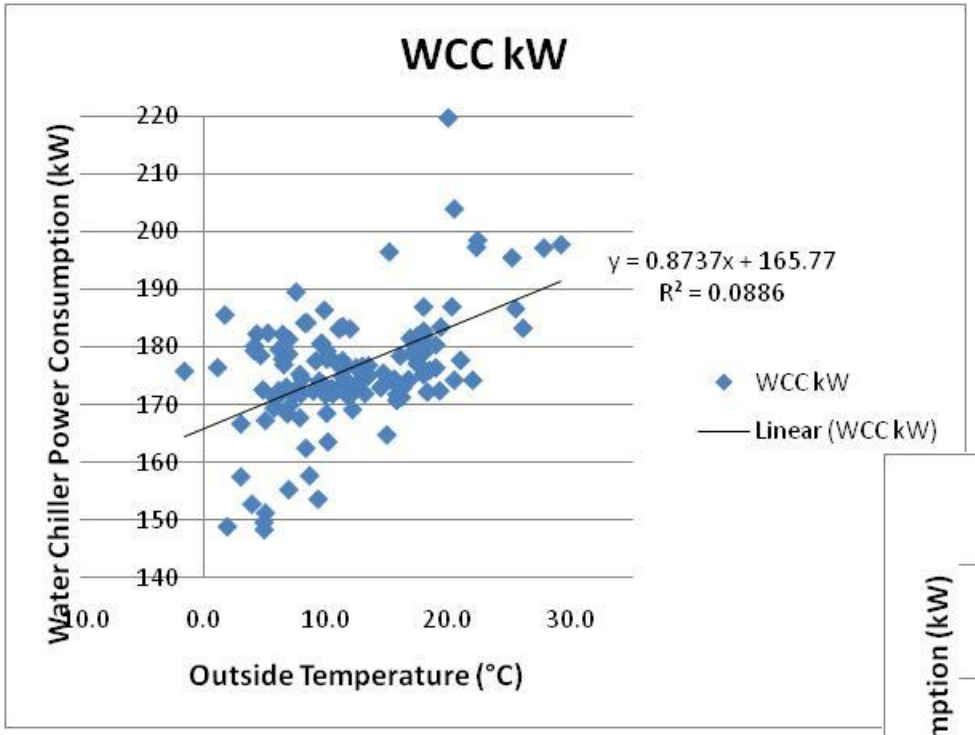
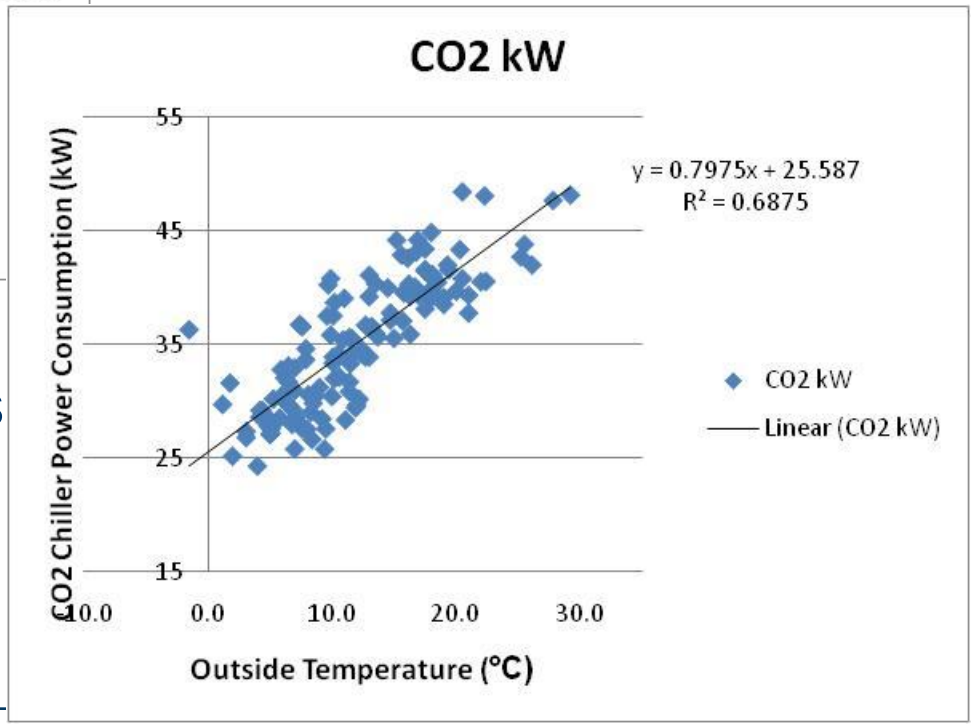
Chillers Power Consumption Compared



- CHW power consumption ranges between 150 and 200 kW; overall average: 175 kW (±15%)



- CO_2 power consumption ranges between 25 and 50 kW; overall average: 35 kW (±30-40%)

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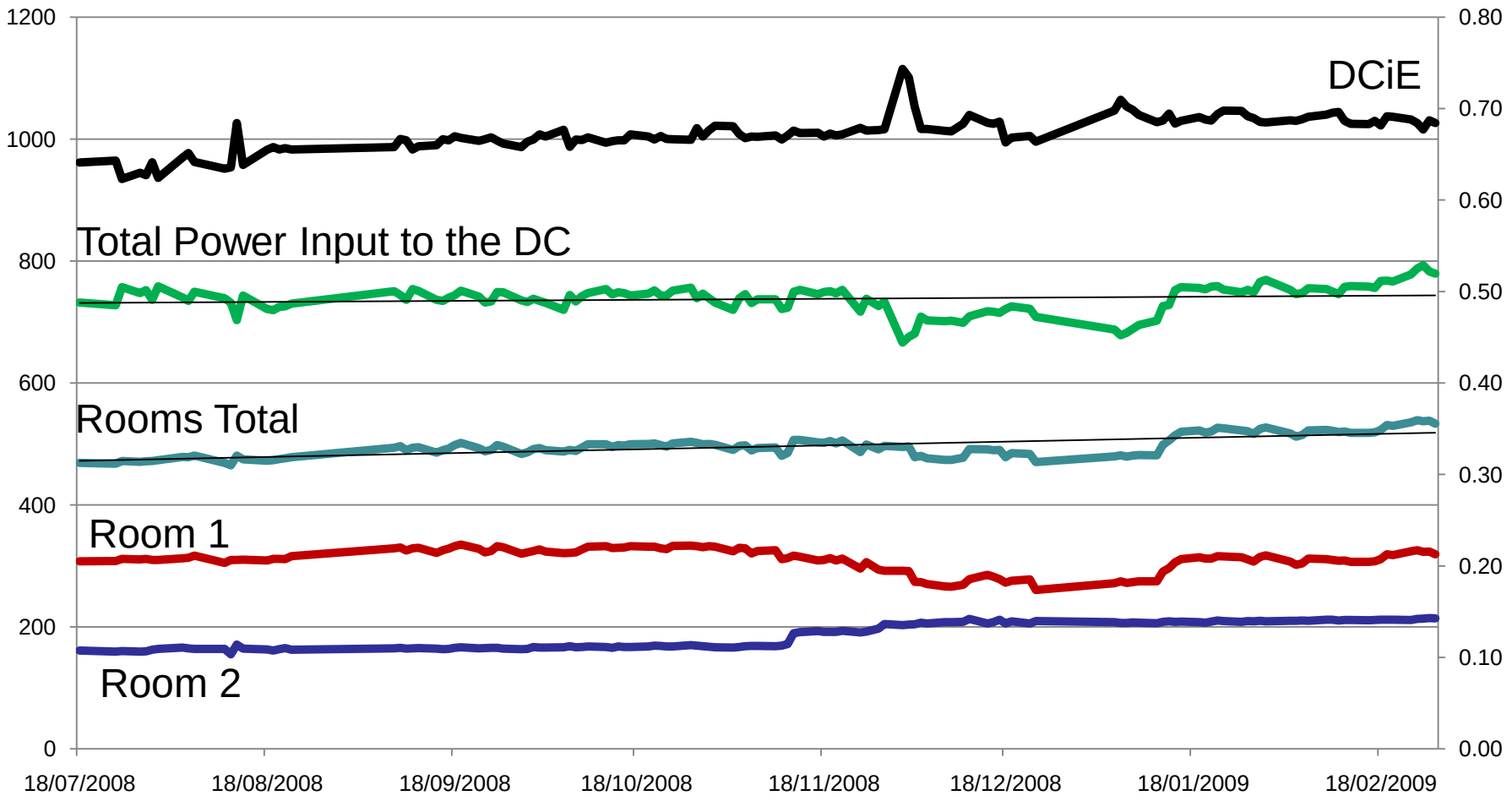
Overall Power Consumption and DCiE



Total UPS power consumption of the DC is around 67 kW

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Energy Analysis – Chilled Water vs. CO_2

- System Comparison:
- # 1: 75% CO_2 + 25% CHW CRAC
- # 2: 100% CHW CRAC
- 24x7x365 peak equipment loads
- Solar and fabric gains omitted
- Excludes humidifier loads

System Duty / Size kW	Power Consumption/kW Cooling	
	System 1: CO_2 System kW	System 2: Chilled Water System kW
250	0.369	0.506
500	0.344	0.496
750	0.326	0.499
1000	0.327	0.502

Data courtesy: hurleypalmerflatt

Suggests 30% better efficiency with CO_2 cooling versus Chilled Water

Cooling Efficiency of CO_2 at Imperial

- Efficiency calculated in cooling power per server kW
- Water Cooled Chiller – 13 CRAC units
- Only Traditional cooling in Room 2 (8 CRAC units)
  - kW cooling = 175 x (8/13) = 108 kW

Efficiency = 108 / 200 = 0.54

- CO_2 coupled cooling in Room 1 (5 CRAC units)
  - kW cooling = 175 x (5/13) = 67 kW

Efficiency = (67 + 35) / 300 = 0.34

Turning out as providing around 40% better efficiency

Conclusions

- Space savings
  - Server Density
  - Two times less space)
- Power savings
  - Used in conjunction with a chilled water system
  - Bringing about 25-45% more efficiency
- Good reliability record
  - Design should be carefully thought for mission critical systems
  - 1+1 would be expensive
  - Mixing production / non-production

Questions

Enclosed Cold Aisle