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The Effect of Data Centre Environment on IT Reliability & Energy Consumption

Steve Strutt
EMEA Technical Work Group Member
IBM

Agenda

- History of IT environmental operating ranges
  - Increasing data centre efficiency
  - Concerns with operating at higher temperatures
- IT reliability and temperature
- Using the ASHRAE classes
  - Exploiting the allowable range
  - IT Reliability in the allowable range
- Higher operating ranges
  - ASHRAE 2011 classes
  - Effect on chiller hours
- Implications
  - IT hardware design
  - Data Centre design
- Further information

History of IT Operating Ranges

- 20°C considered optimal operational temperature
  - Intended for punched cards?

- ASHRAE
  - TC 9.9 - Mission Critical Facilities, Technology Spaces, and Electronic Equipment
  - 2004, 2008 guidance
    - Recommended range
    - Allowable range

	Recommended		Allowable	
Year	**2004**	**2008**	**2004**	**2008**
Temperature range	**20°C - 25°C**	**18°C - 27°C**	**15°C - 32°C**	**10°C - 35°C**
Moisture range	**40% - 55% RH**	**5.5° C DP – 60% RH**	**20%- 80% RH**	**20%- 80% RH**

Source: ASHRAE Whitepaper – 2011 Thermal Guidelines for Data Processing Environments

Increasing Data Centre Efficiency

- Increasing usage of economizers
  - Reduce costs by increasing number of hours that economizers can be used
    - Direct air cooled, indirect air cooled, indirect water cooled.
  - Reduce size of chiller plant or remove all together
- Higher return temperatures to increase cooling efficiency
  - Contained aisle solutions
    - Stop air mixing and recirculation
    - Elimination of hot spots
- Little change in operating temperatures for most data centres
  - Poor communication between facilities and IT
  - Concern about business impact
    - The effect of temperature and humidity on reliability
    - Industry support and warranties

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Industry Change

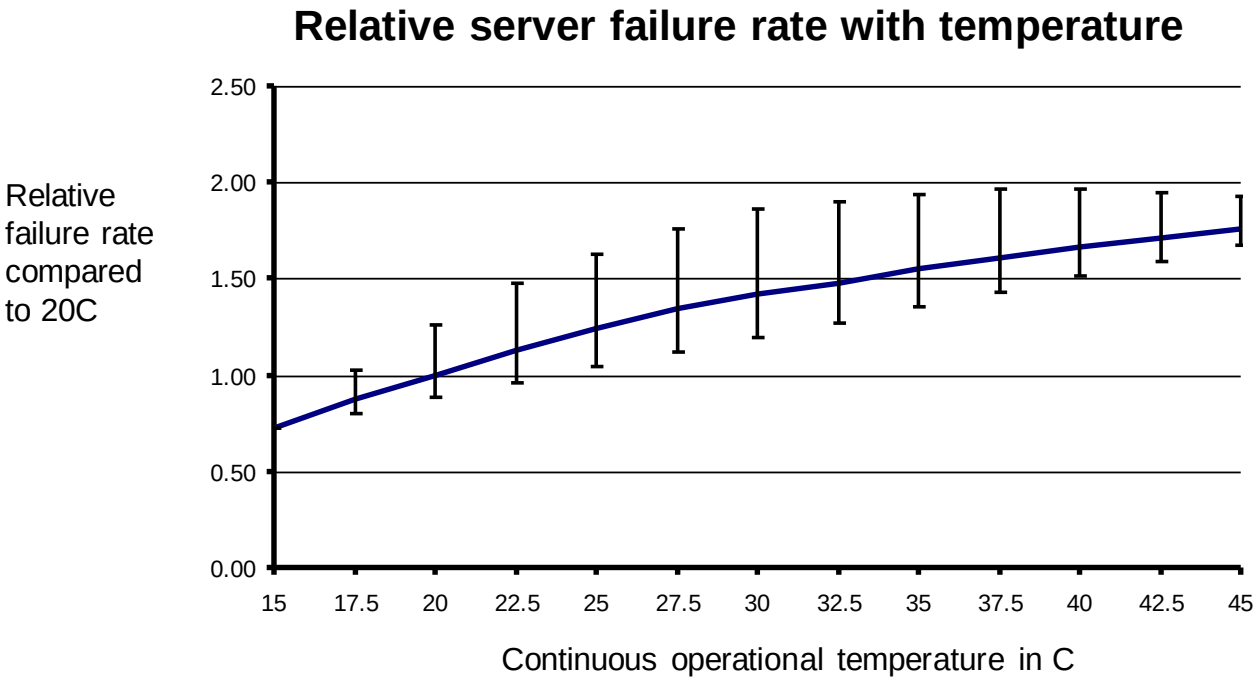
- Rise of cloud computing as a new IT delivery model
  - Early adopters demonstrated viability of higher temperatures
  - Different approach to systems availability
    - Reliability at the software and application layer
    - Enterprise IT model assumes high infrastructure reliability
- Intel study
  - Traditional DC with supply temperatures of approximately 20°C resulted in a failure rate of 2.5% to 3.8% over twelve months
  - Similar data centre using an air-side economizer with temperatures occasionally ranging to 35°C the failure rate was 4.5%
    - Note no classification of the hardware failures was performed
  - http://www.intel.com/content/www/us/en/data-center-efficiency/data-center-efficiency-xeon-reducing-data-center-cost-with-air-economizer-brief.html

Concerns With Higher Operating Temps

- Lack of data on change of reliability with temperature
- Increasing server energy consumption with temperature
  - Server fan power
  - Silicon leakage current
- Older equipment
  - Rapid change in environmental support in last 4 years
- Current models support higher ranges
  - Blades
    - Cisco UCS: 10-35°C, 10%-90%
    - IBM BladeCenter HS22: 10-35°C, 8%-80%
    - HP BL490c G6: 10-35°C, 10%-90%
  - Switches
    - Cisco Nexus 5000: 0-40°C, 5%-90%
  - Storage
    - EMC Symmetrix V-MAX: 10-32°C, 20%-80%
    - NetApp 10-40°C, 20%-80%

Source: Information from vendors websites

IT Reliability and Temperature



Source: ASHRAE Whitepaper – 2011 Thermal Guidelines for Data Processing Environments

- Manufacturer's data in ASHRAE 2011 guidance shows moderate increasing failure rate with temperature
  - Limited duration operation above 20^{O}C has marginal impact on overall failure rate
  - Operation below 20^{O}C reduces failure rate

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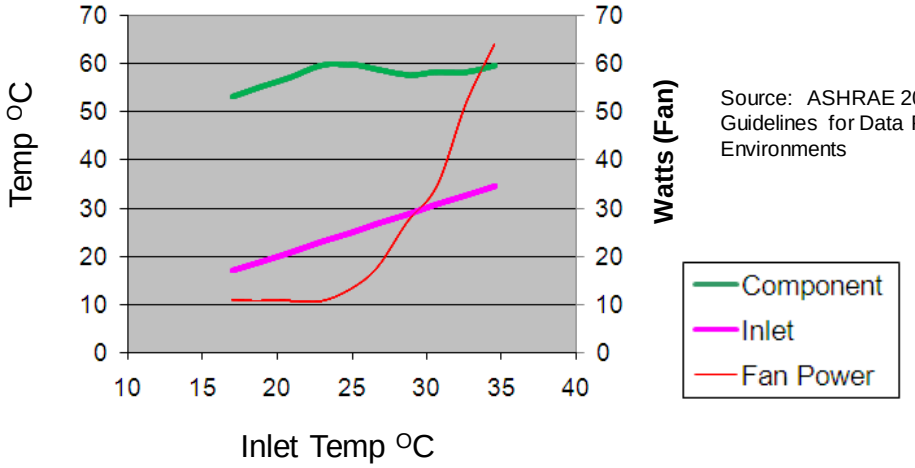
Power Consumption With Temperature

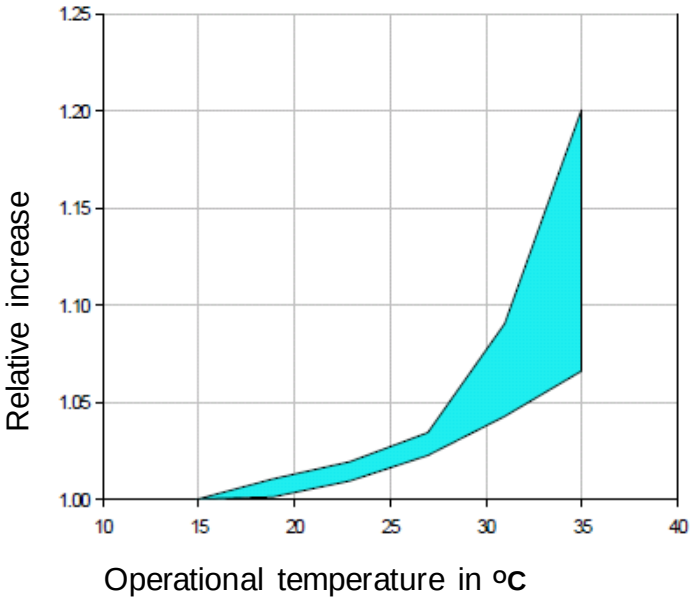
Fan power consumption and component temperature



Source: ASHRAE 2008 Thermal Guidelines for Data Processing Environments

- Fan power consumption increases as a cube of the airflow rate
- Large fans consume less energy and create less noise for the same airflow

Relative server power increase compared to 15°C inlet temperature



Source: ASHRAE Whitepaper – 2011 Thermal Guidelines for Data Processing Environments

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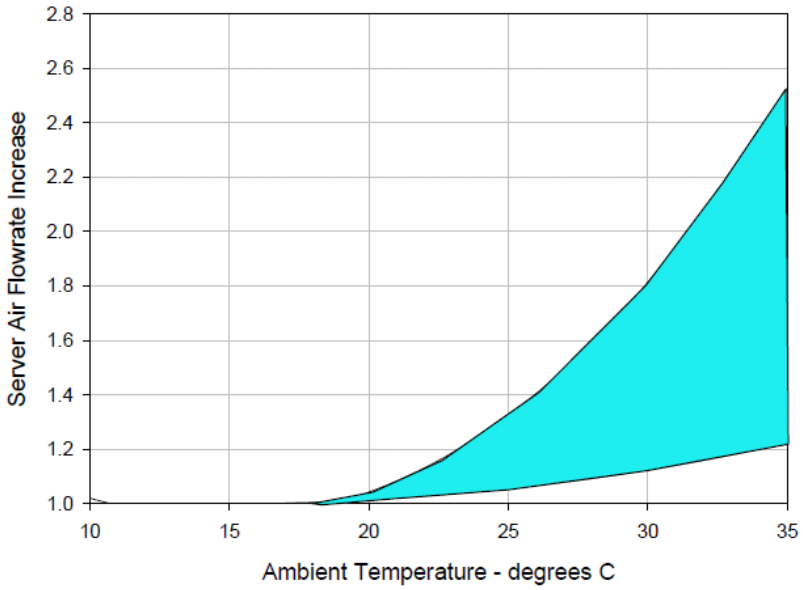
Higher Inlet Temperatures

- Power
  - Increase by up to 20%
- Airflow
  - Can double by 35^{O}C
  - Requires improved air flow design
  - Increased failure rate if starved
- Noise
  - Increases as 5th power of rotational speed
  - Exceed health and safety guidelines
- Exhaust temperature
  - Can be 20^{O}C more than inlet
  - Exceed health and safety guidelines

Air flow increase with ambient temperature



Source: ASHRAE Whitepaper – 2011 Thermal Guidelines for Data Processing Environments

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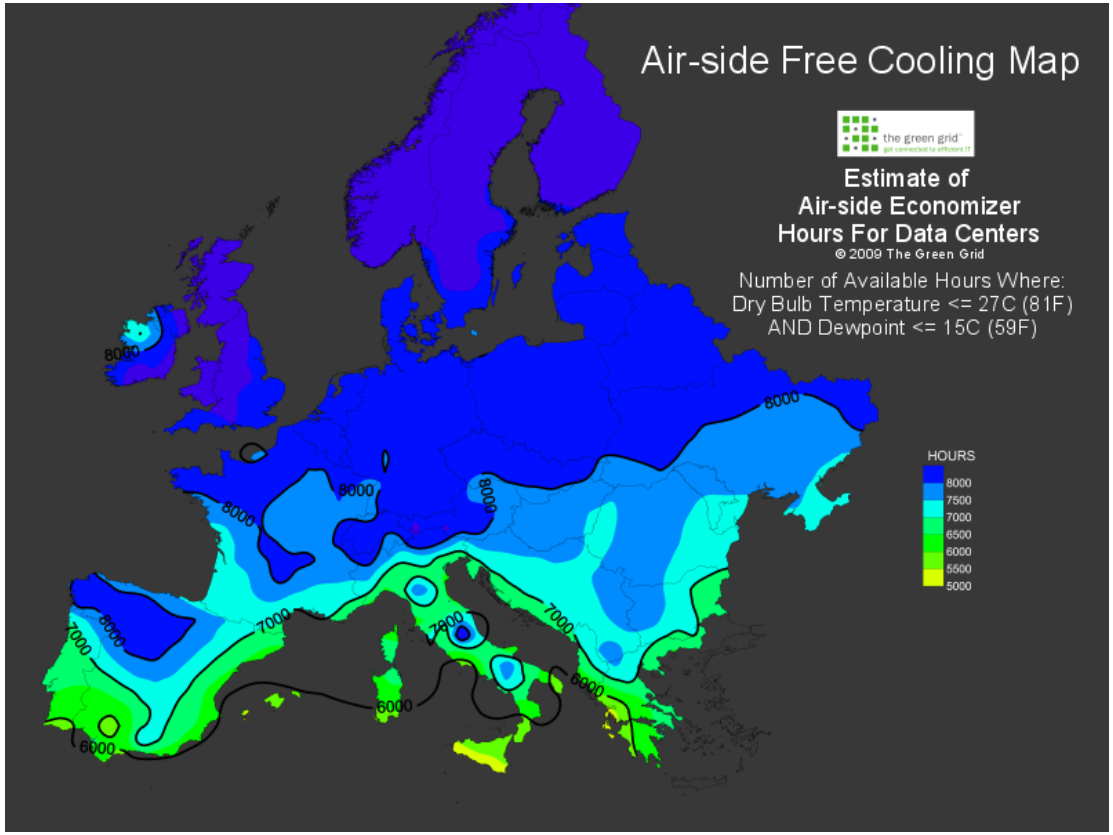
Using The ASHRAE Classes

The Green Grid has identified that much of Europe can benefit from air side economizers while remaining within ASHRAE Class 2 **Recommended** upper guideline of 27^{O}C



Hours per year when dry bulb temperature less than or equal 27^{o}C

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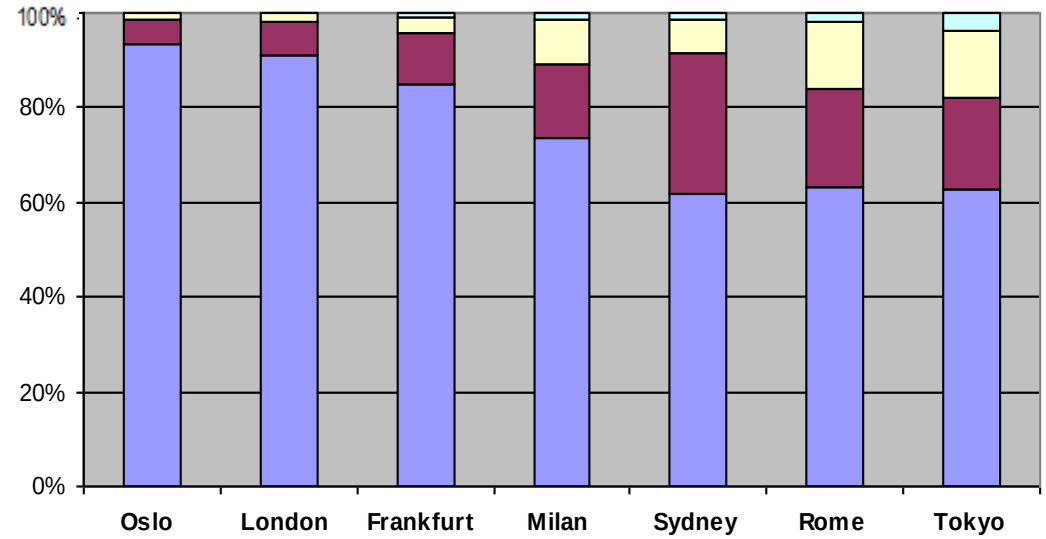
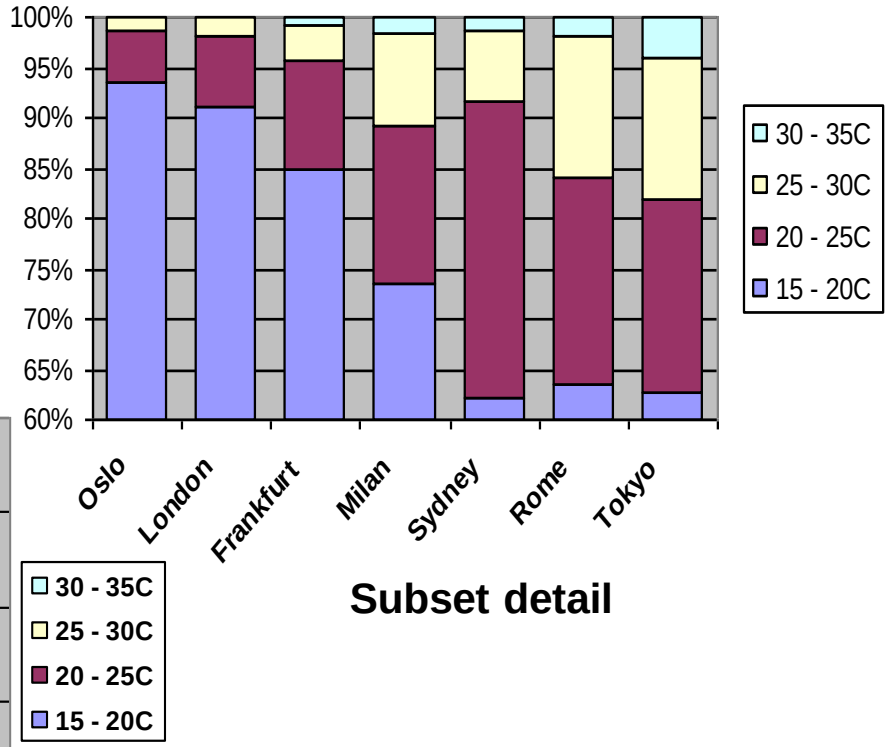
Exploiting the Allowable Range

- ASHRAE Class 2
  - **Recommended** range
    - 15ºC to 27ºC
  - **Allowable** range
    - 10ºC to 35ºC





Subset detail

Economised air temperature by percentage of time for major cities

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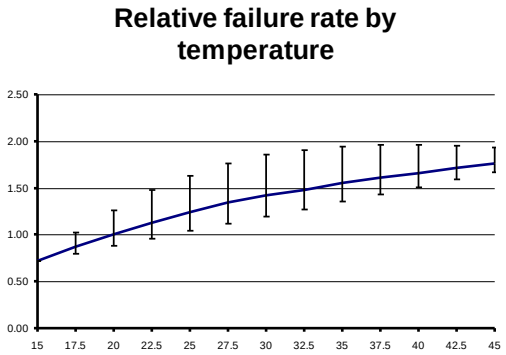
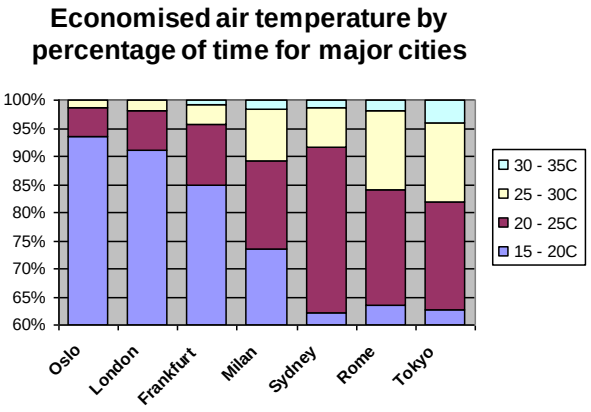
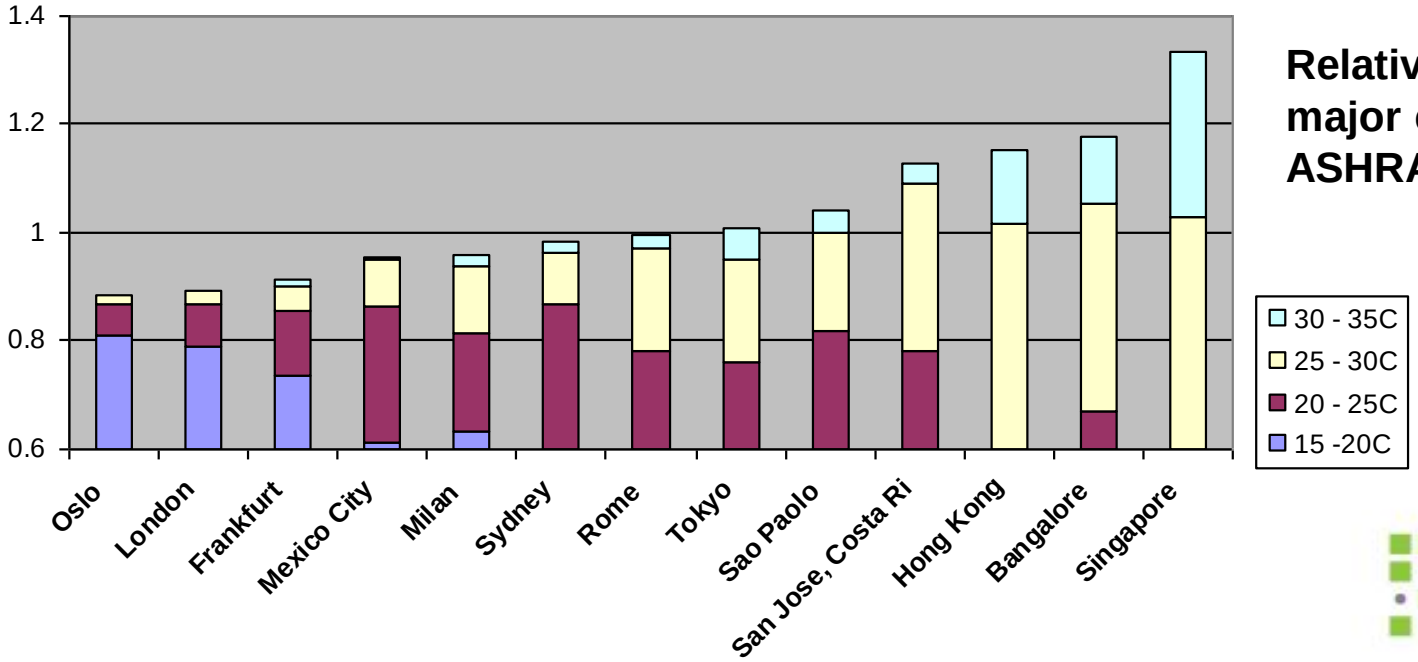
Reliability within Allowable Range







Relative failure rate for major cities within ASHRAE allowable range

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Higher Operating Ranges

- ETSI EN 300 019 Class 3.1 (NEBS)
  - Operation up to 45ºC
  - Small number of server models available
  - Usually limited performance compared to volume models
  - Higher cost
- ASHRAE 2011 guidelines

Comparison of ASHRAE 2008 and 2011 classes

2011 classes	2008 classes	Applications	IT Equipment	Environmental Control
A1	1	Datacenter	Enterprise servers, storage products	Tightly controlled
A2	2		Volume servers, storage products, personal computers, workstations	Some control
A3	NA		Volume servers, storage products, personal computers, workstations	Some control
A4	NA		Volume servers, storage products, personal computers, workstations	Some control
B	3	Office, home, transportable environment, etc.	Personal computers, workstations, laptops, and printers	Minimal control
C	4	Point-of-sale, industrial, factory, etc.	Point-of-sale equipment, ruggedized controllers, or computers and PDAs	No control

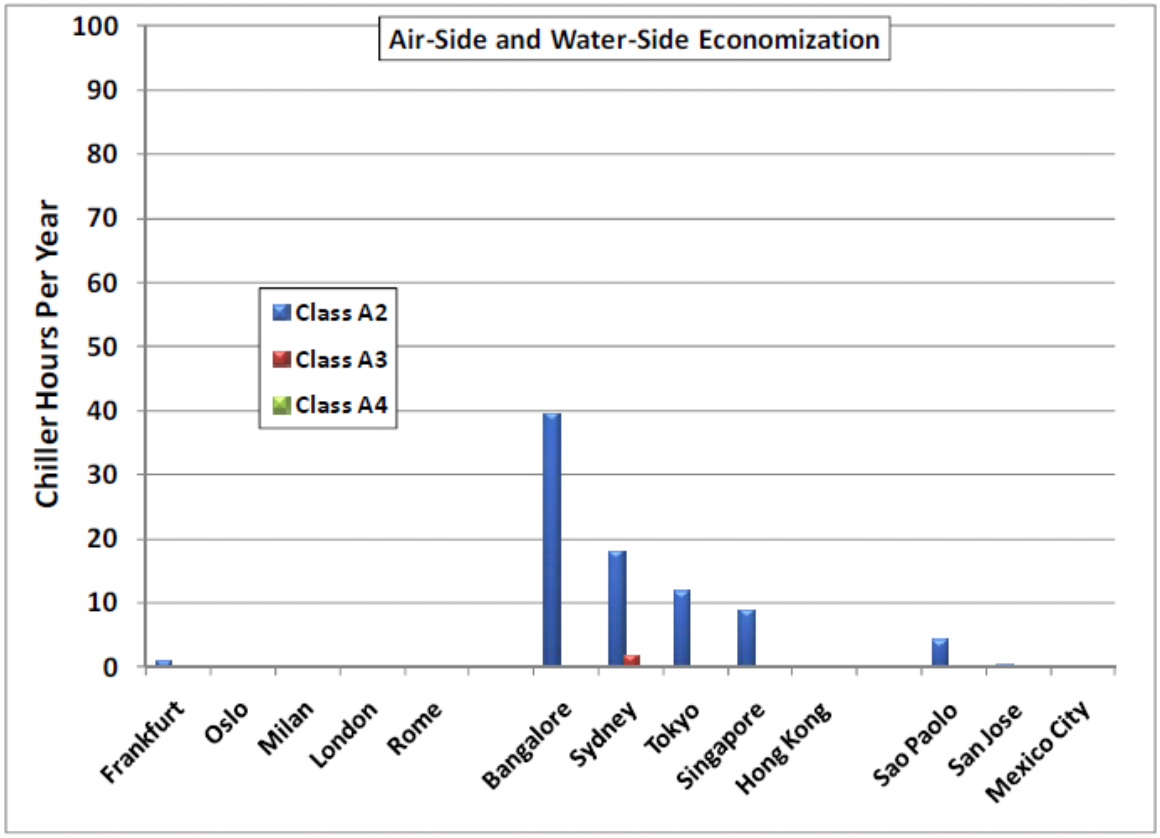
Source: ASHRAE Whitepaper – 2011 Thermal Guidelines for Data Processing Environments

ASHRAE Expanded Data Centre Classes

Equipment Environmental Specifications					
Classes	**Product Operation**				
	Dry-Bulb Temperature (°C)	**Humidity Range non-Condensing**	**Maximum Dew Point (°C)**	**Maximum Elevation (m)**	**Maximum Rate of Change (°C/hr)**
Recommended					
A1 to A4	**18 to 27**	**5.5C DP to 60% RH and 15C DP**			
Allowable					
A1	**15 to 32**	**20 to 80% RH**	**17**	**3040**	**5/36**
A2	**10 to 35**	**20 to 80% RH**	**21**	**3040**	**5/36**
A3	**5 to 40**	**8 to 85% RH**	**24**	**3040**	**5/36**
A4	**5 to 45**	**8 to 90% RH**	**24**	**3040**	**5/36**
B	**5 to 35**	**8 to 85% RH**	**28**	**3040**	**NA**
C	**5 to 40**	**8 to 85% RH**	**28**	**3040**	**NA**

Source: ASHRAE Whitepaper – 2011 Thermal Guidelines for Data Processing Environments (Reformatted)

Chiller Hours When Using Economizers



Number of hours per year of chiller operation required for air-side and waterside economizer for ASHRAE classes

Source: ASHRAE Whitepaper – 2011 Thermal Guidelines for Data Processing Environments

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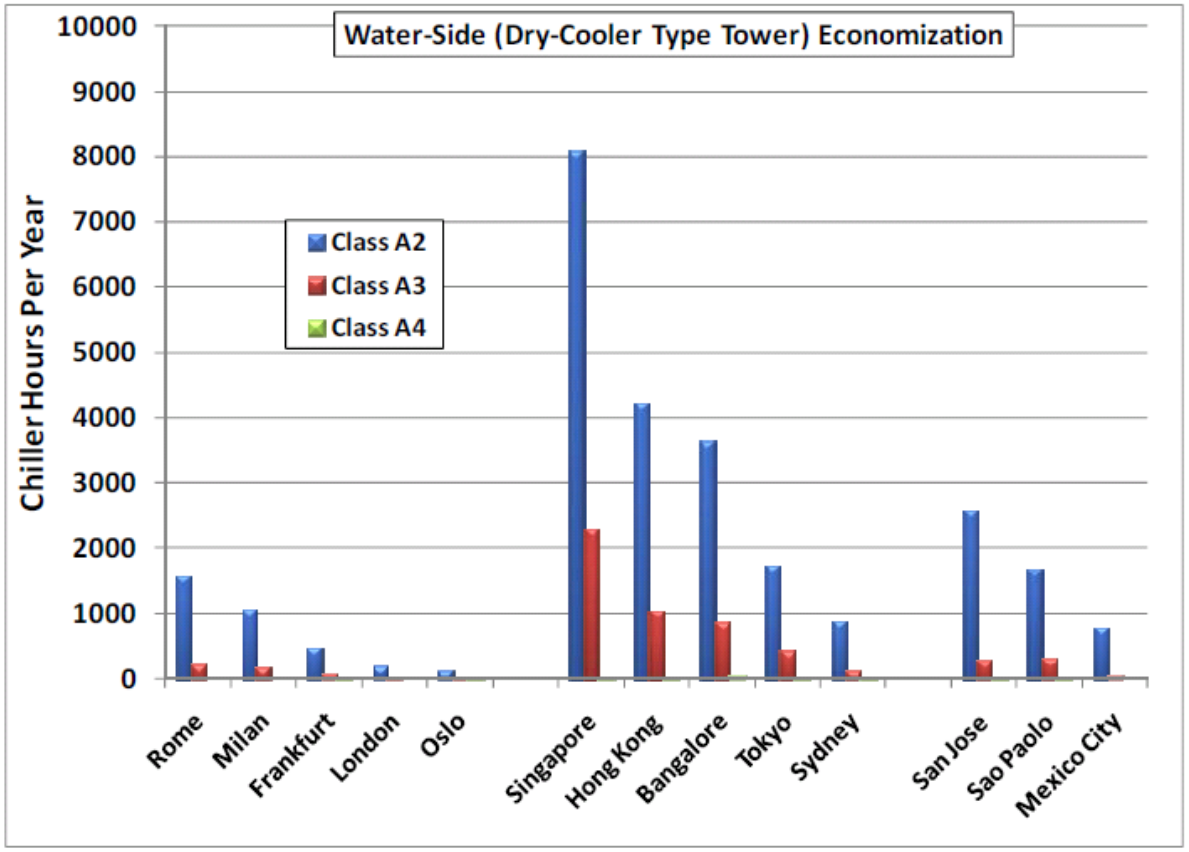
Chiller Hours Using Closed Loop Cooling



Number of hours per year of chiller operation required for a water-side economizer with a dry-cooler type tower for ASHRAE classes

Source: ASHRAE Whitepaper – 2011 Thermal Guidelines for Data Processing Environments

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Implications for Design of IT Equipment

- Lower temperature differential across hot components (Delta T)
  - Intel processors typically run at 60^{O}C
- Greater airflow required
- Larger heat sinks

- New server form factors
  - Heat dissipation of 1U servers is limited by fan and headsink size
  - Reduced fan power consumption and noise

- Expectations of warranty and reliability
- Costs of classes A3/A4 compared to A1/A2
- Future fan-less servers and water cooling

Implications For Design of Data Centres

- Higher data centre airflow
- Temperature and noise in hot aisle
- Humidity and corrosion effects
- Are chillers required?
- Ride through time on cooling plant failure
- PUE anomalies due to server fan power at high temperatures

- Redundant IT service design and workload migration
  - Requires holistic approach to IT and DC
- Water cooling

- Server replacement costs are lower than investment costs in plant and electricity
- IT service level requirements

Further Information

- 2011 Thermal Guidelines for Data Processing Environments – Expanded Data Centre Classes and Usage Guidance
  - http://tc99.ashraetcs.org/documents/ASHRAE Whitepaper - 2011 Thermal Guidelinesfor Data Processing Environments.pdf

- Deutsche Bank - Banking on Fresh AirEco Data Centre New York
  - http://www.banking-on-green.com/en/content/news_3604.html
  - http://www.thegreengrid.org/library-and-tools.aspx

- British Computer Society

  "IT environmental range and data centre cooling analysis"
  - http://dcsg.bcs.org/data-centre-cooling-analysis

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Thank you for attending!

Questions?