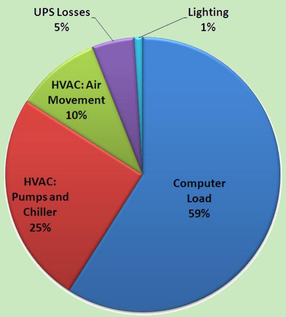
Evaluating Economizer Use in Data Centers

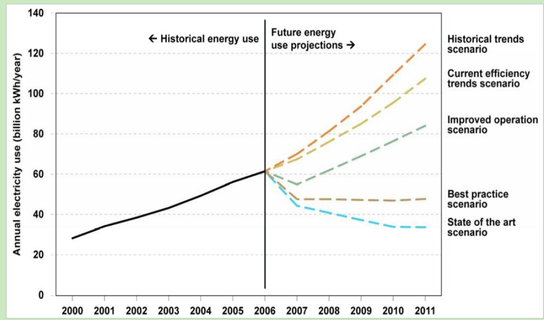
Benjamin Chu, Srirupa Ganguly, Ashok Gadgil
Lawrence Berkeley National Laboratory
University of California, Berkeley

PROBLEM: DATA CENTER ENERGY USE

- Data centers must run 24 hours a day.
- Consume large amounts of energy (60 TWh/year).
- 1.5% of the total electricity generated in the US.
- The chiller is a significant energy consumer (25%)



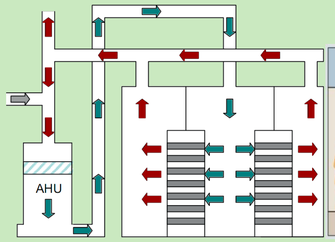
Typical data center energy use breakdown [1].



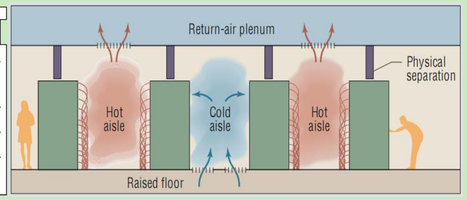
Data center annual electricity use [2].

SOLUTION: AIR SIDE ECONOMIZERS

- Turn off the chiller and bring in cool outside air.
- Reduction of operating hours lowers the energy costs.
- Maintained below 68°F and within 40-55% relative humidity.
- ***Problem: Bringing in outside air increases indoor particle concentrations.***



Typical data center layout [3].



Hot and cold aisles prevent mixing [4].

CONCERNS : PARTICULATE MATTER

- Particles reduce reliability:
  - Cause corrosion.
  - Bridge electrical isolation between conductors.
- Industry is hesitant to install economizers because particles can negate energy savings.
- ***Objective: Find out how economizers impact indoor air quality.***

Corrosion coupons measure corrosion rates for different metals.

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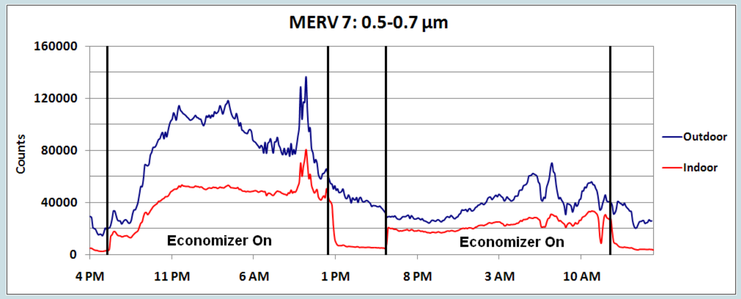
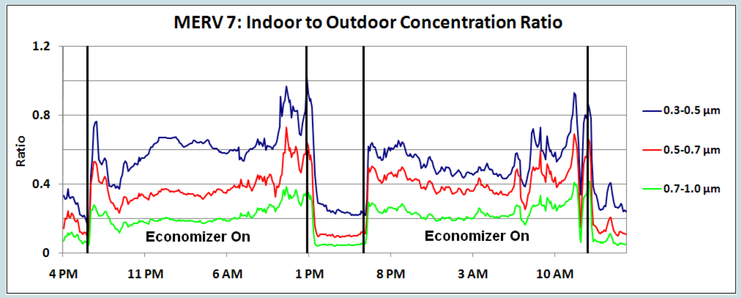
RESULTS: SIZE RESOLVED DATA

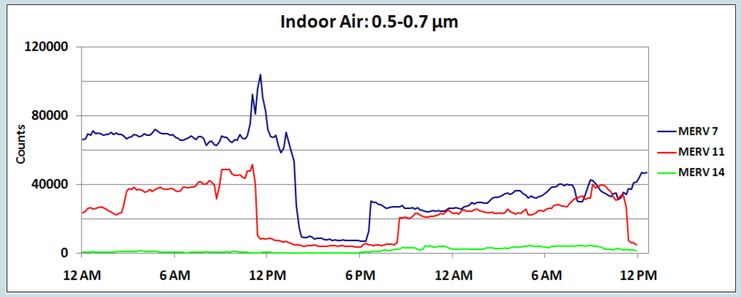


Comparison of indoor and outdoor counts. Indoor concentrations are sensitive to outdoor concentrations when the economizer is on, causing them to rise.

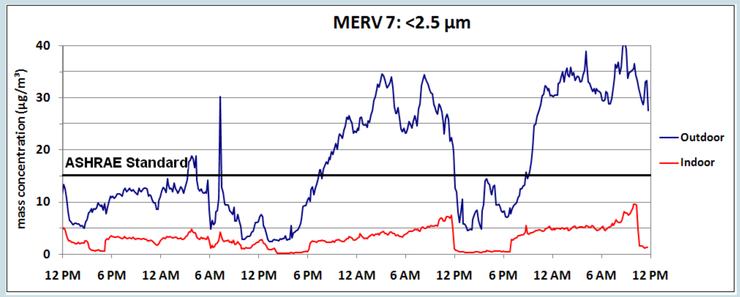


Comparison of indoor to outdoor concentration ratio for different size ranges. Larger particles are filtered more efficiently.

RESULTS: FILTER EFFICIENCY



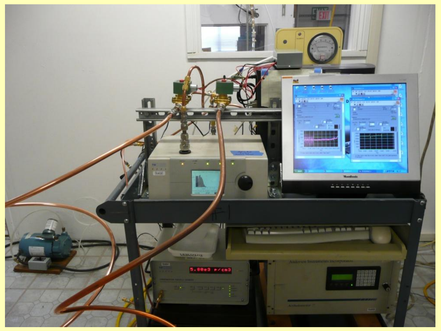
Indoor air counts for different MERV filters. The higher rated filters are more efficient at filtering out particles.



Comparison of concentrations to the ASHRAE standard for particulate matter smaller than 2.5 µm diameter (15.0 µg/m³) [5]. Data collected when a MERV 7 filter (weakest filter in the study) was in use, as a conservative estimate. Indoor concentrations are well below the standard, even though the outdoor concentrations exceed it.

METHODS: AEROSOL ANALYSIS

- Count particles for analysis.
- Compared 3 different MERV filters.
- Optical measurement devices:
  - Aerodynamic particle sizer: Size resolved data.
  - Optical particle counter: Size resolved data.
  - Condensation particle counter: Smaller particles.
  - Aethalometer: Carbon data.



Aerosol setup samples air inside and outside the data center.

METHODS: CHEMICAL ANALYSIS

- Identify particles for analysis.
- Two setups:
  - Annular denuder, followed by Teflon, nylon and cellulose filters.
  - Two quartz filters.
- Nitrates, sulfates and ammonia are hygroscopic.
- Chemical speciation by ion chromatography.

Filter setup collects particles inside and outside the data center.

DISCUSSION AND CONCLUSION

- Larger particles are filtered more effectively.
- When the economizer is on, indoor particle concentrations increase.
- Higher MERV rated filters are more effective, but not necessary.
- ***Indoor concentrations are lower than ASHRAE standards, therefore, economizers are suitable for data center use.***

FURTHER WORK

- Model economizer cost implications for different climates.
- Portable ambient air analyzers track SF_6 tracer gas to measure diffusion rate.

REFERENCES

[1] Greenberg et al, 2006, *Best Practices for Data Centers*
[2] LBNL, 2007, *Report to Congress on Server and Data Center Energy Efficiency*
[3] Shehabi et al, 2008, *Particle Concentrations in Data Centers*
[4] Tschudi et al, 2006, *Measuring and Managing Data-Center Energy Use*
[5] ASHRAE, 2005. *Design considerations for data and communications equipment centers.*