



Evaluating Data Center Indoor Air Quality



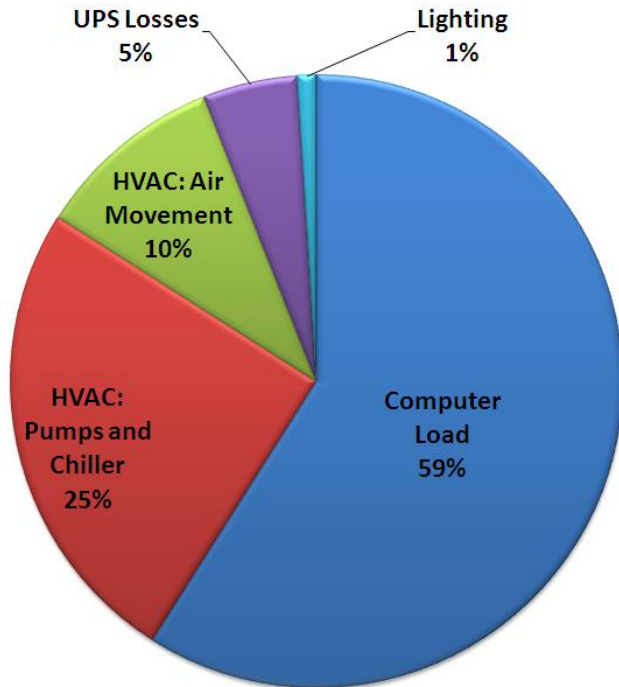
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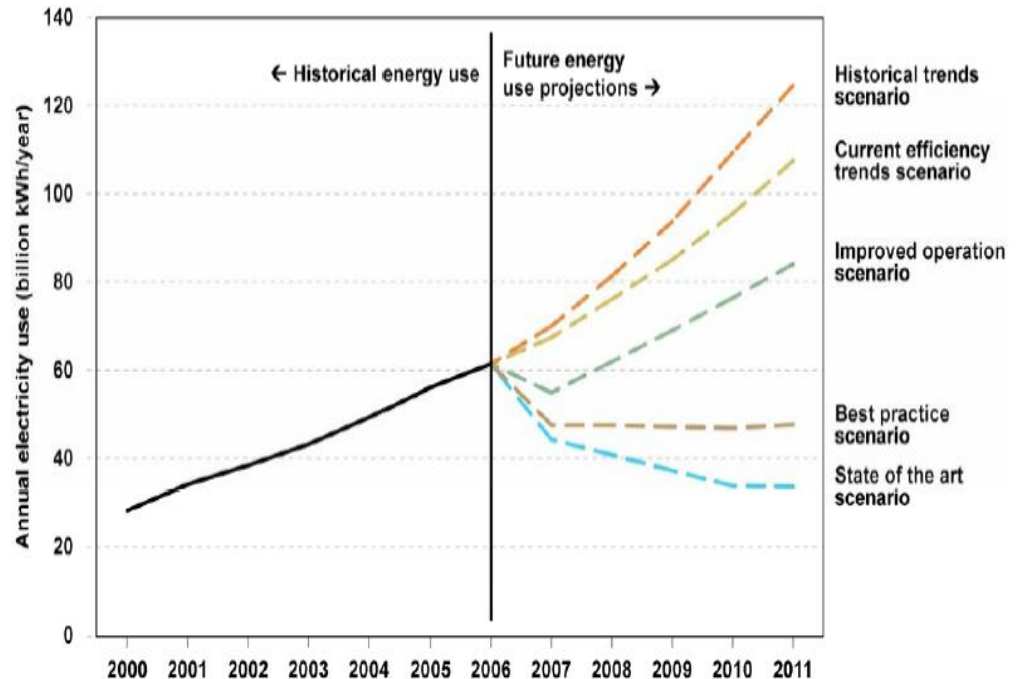


Data Center Energy Use

- Data centers must run 24 hours a day.
- Data centers consume large amounts of energy (60 TWh/year) [1].
- 1.5% of the total electricity generated in the US.
- Chillers are a significant energy consumer in data centers (25%) [2].



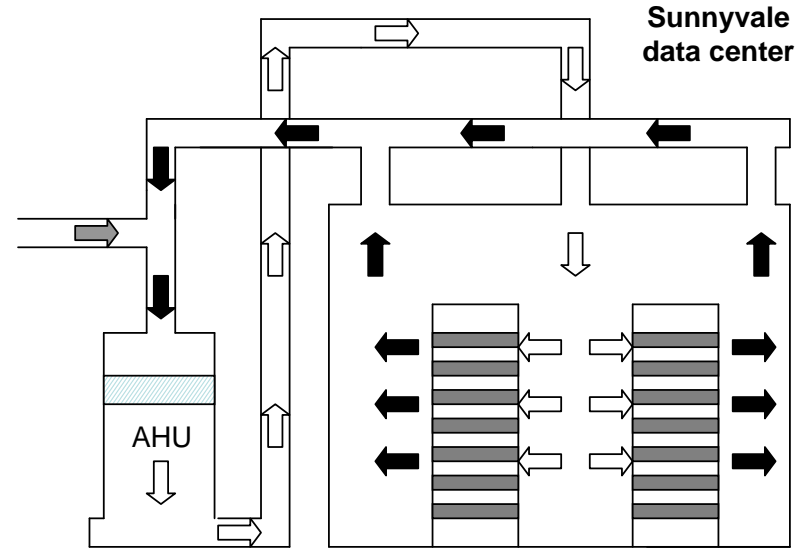
Greenberg et al, 2006, *Best Practices for Data Centers*



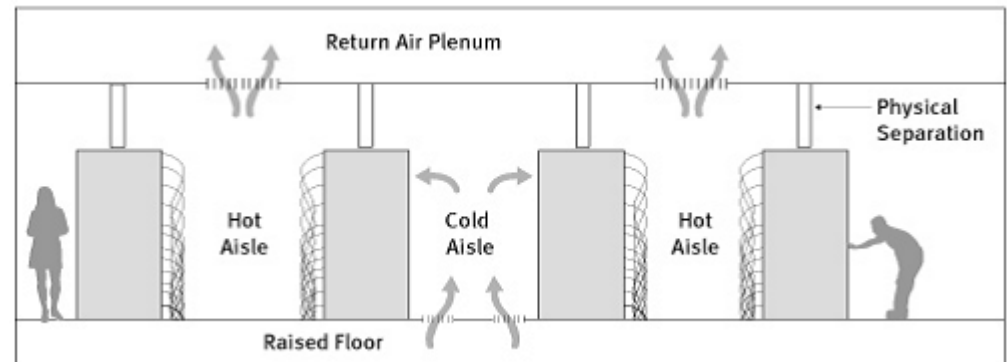
LBNL, 2007, *Report to Congress on Server and Data Center Energy Efficiency Public Law 109-431*

Air Side Economizers

- Turn off the chillers and bring in cool outside air.
- This reduction of operating hours lowers the energy costs.
- Problem: Bringing in outside air increases indoor particle concentrations.



Shehabi et al, 2008, *Particle Concentrations in Data Centers*



Tschudi et al, 2006, *Measuring and Managing Data-Center Energy Use*

Particulate Matter

- **Contaminants can:**
 - Corrode metal contacts.
 - Bridge the electrical isolation between conductors.
- **Objective: Find out how economizers impact indoor air quality.**

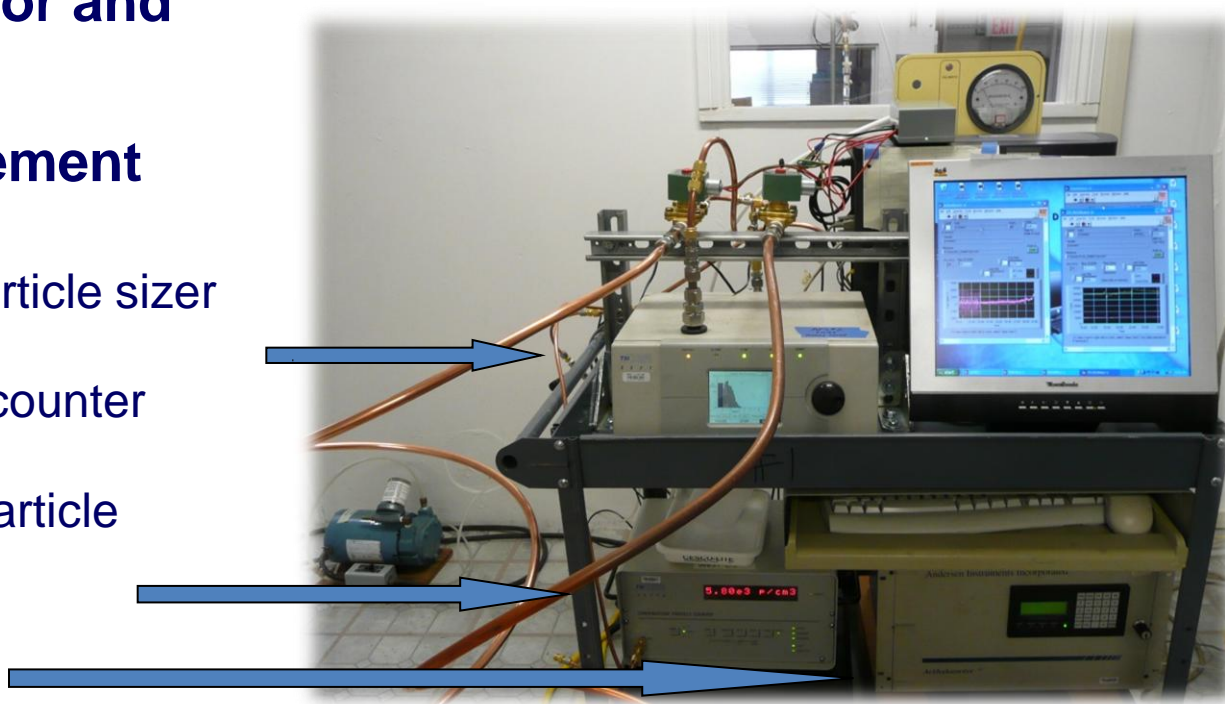


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Corrosion coupons used to gauge corrosion rates.

Aerosol Analysis

- Count and identify particles in indoor and outdoor air.
- Optical measurement devices:
 - Aerodynamic particle sizer (APS)
 - Optical particle counter (OPC)
 - Condensation particle counter (CPC)
 - Aethalometer



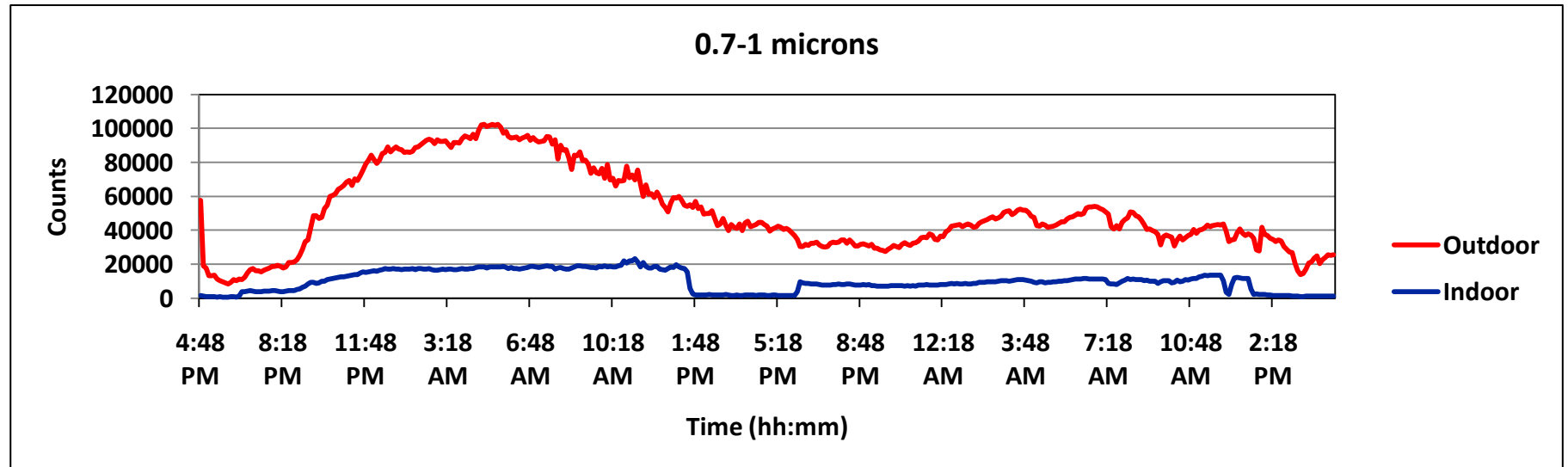
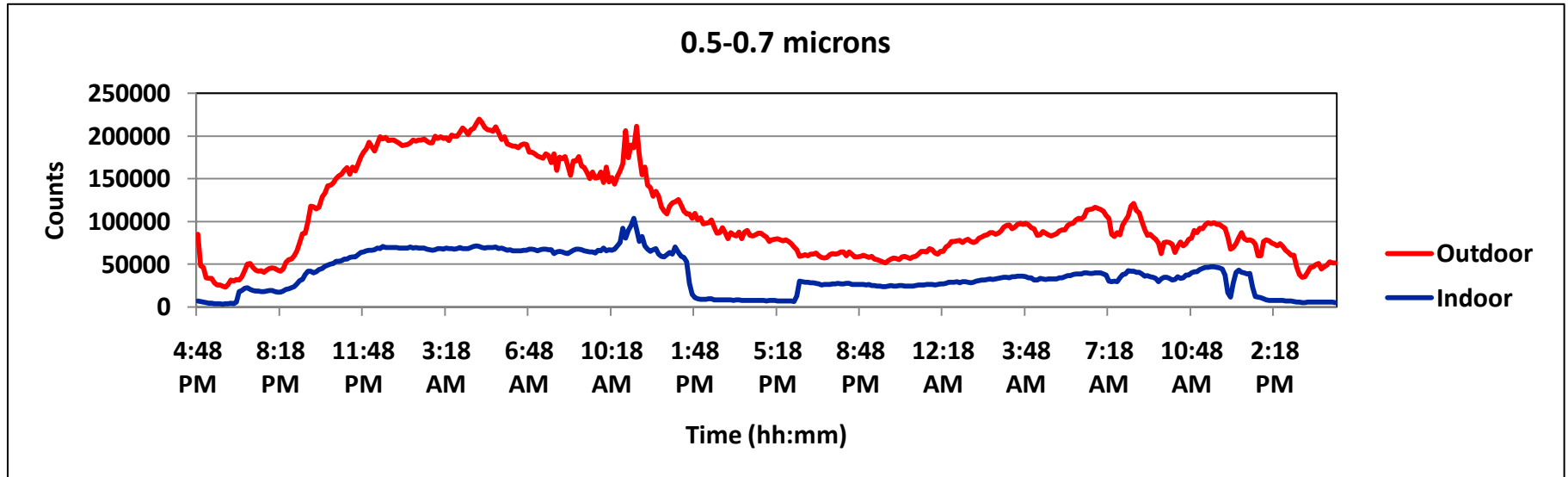
Chemical Analysis

- **Collect indoor and outdoor particles for analysis.**
- **Two different setups:**
 - An annular denuder, followed by Teflon, nylon and cellulose filters.
 - Two quartz filters.
- **Nitrates, sulfates and ammonia are of interest because they are hygroscopic.**
- **Chemical speciation by ion chromatography.**

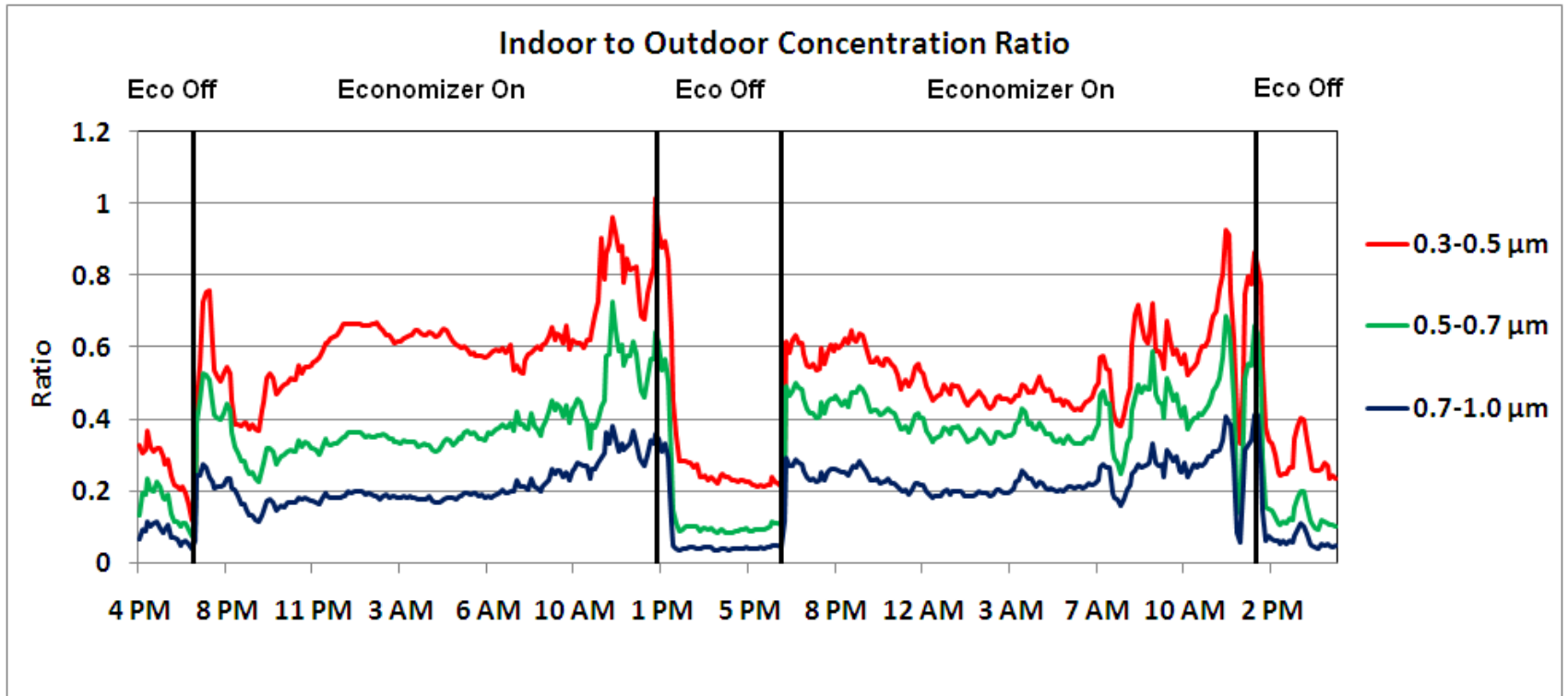


Quartz Filter Denuder

Size Resolved Data for 7/30/08-8/1/08

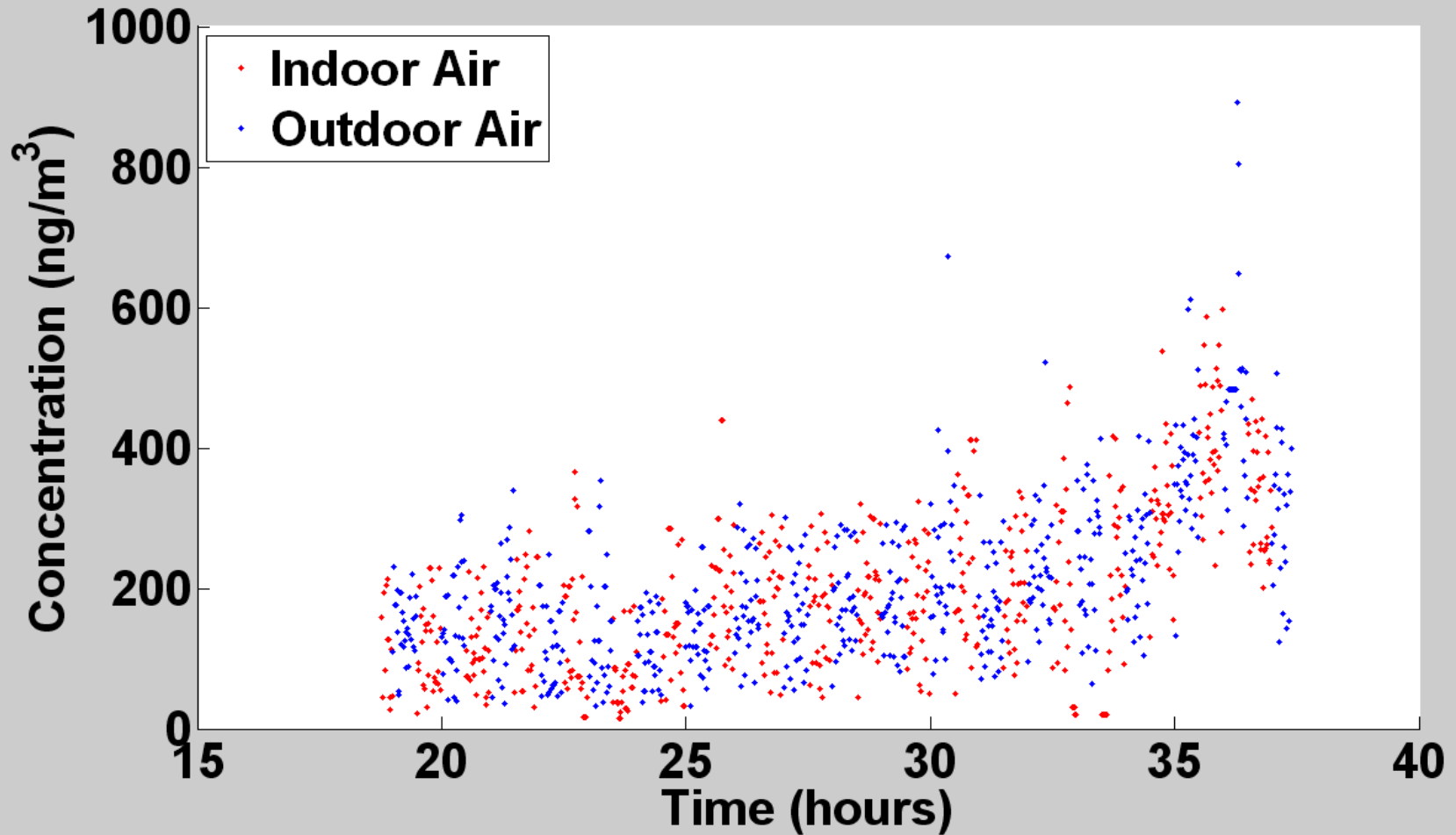


Indoor to Outdoor Concentration Ratio

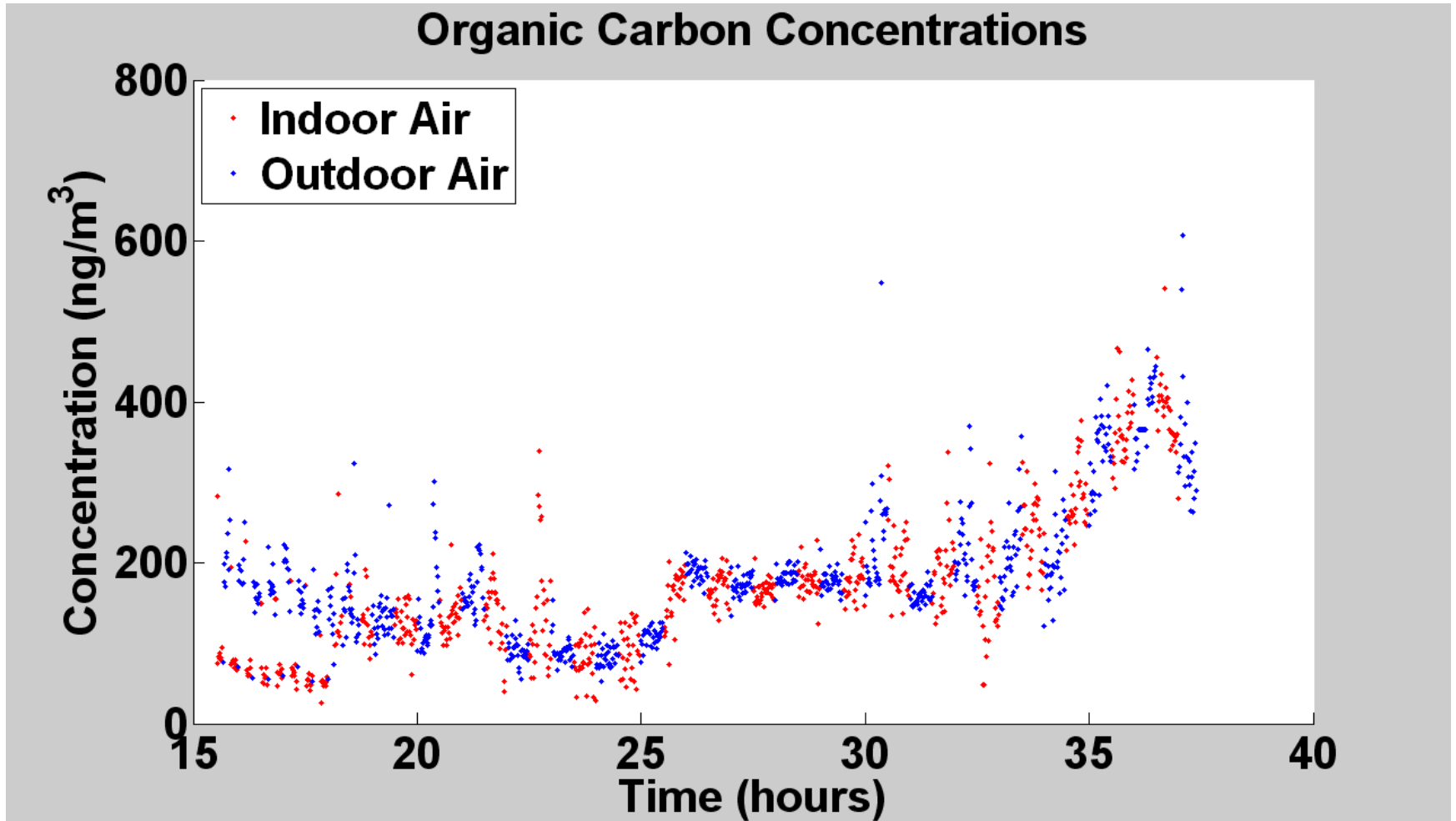


Carbon Data for 8/4/08-8/5/08

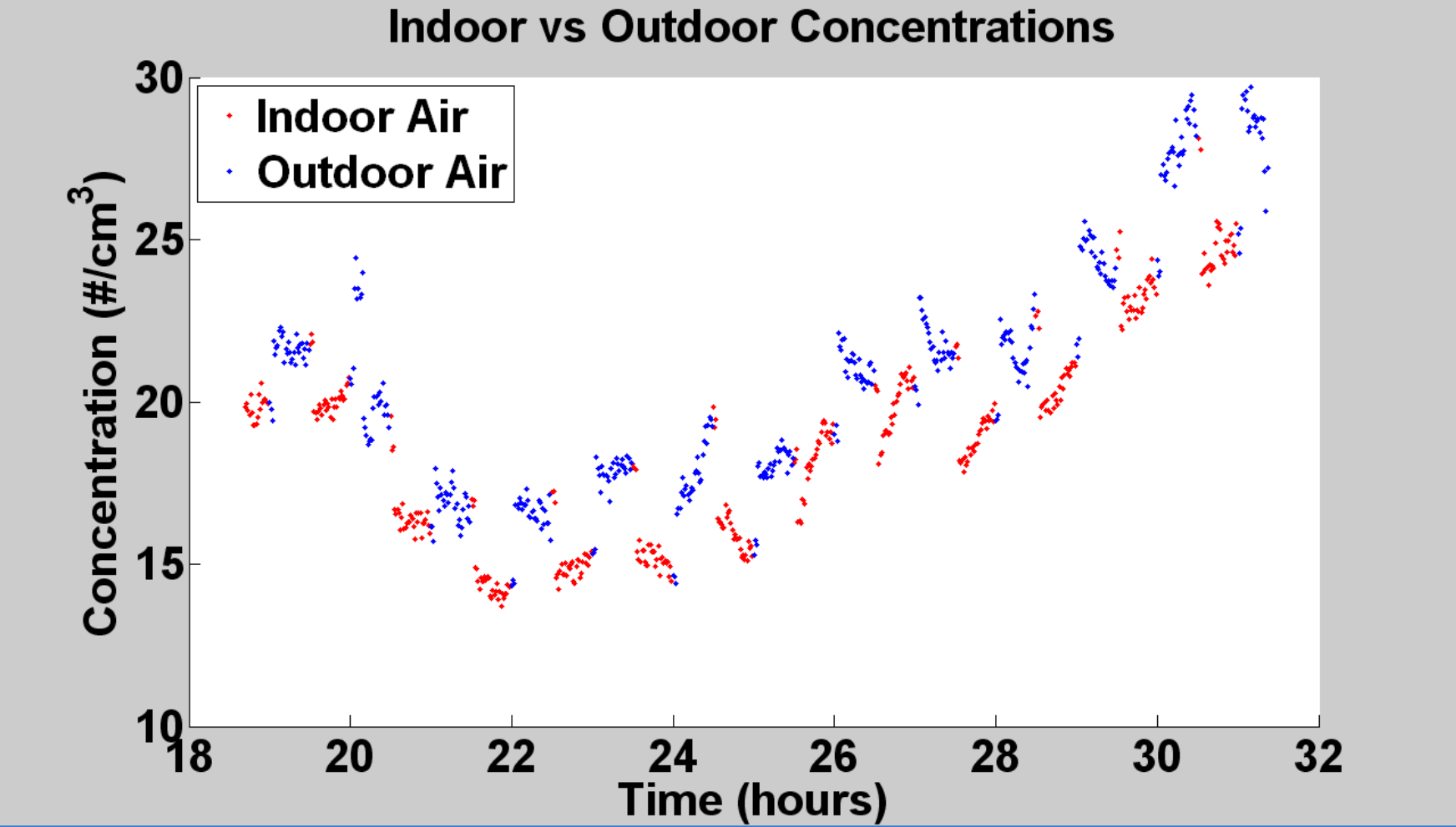
Black Carbon Concentrations



Carbon Data for 8/4/08-8/5/08



Particle Concentrations for 7/31/08-8/1/08





Discussion and Conclusion

- **When the economizer is on, there is an increase of particle counts and concentrations of indoor air.**
- **When it is turned off, the concentrations of indoor air decrease because of recirculation.**
- **Concentrations are lower than EPA standards for particulate matter smaller than 2.5 μm diameter (15.0 $\mu\text{g}/\text{m}^3$).**



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Modeling and Further Work

- **Create a model of economizer cost implications in different climates.**
- **SF₆ is released as a tracer to measure the particle diffusion.**
- **Portable ambient air analyzers are used to track the diffusion rate.**
- **Corrosion coupons measure the corrosion rate of the electronic circuits.**



References

- [1] LBNL, 2007, *Report to Congress on Server and Data Center Energy Efficiency Public Law 109-431*
- [2] Greenberg et al, 2006, *Best Practices for Data Centers*
- [3] Shehabi et al, 2008, *Particle Concentrations in Data Centers*
- [4] Tschudi et al, 2006, *Measuring and Managing Data-Center Energy Use*