Data Center Air-flow Management

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Customer Energy Efficiency
PG&E

PG&E Incentive Programs

Two drivers:

- Simple for our customers
- Light to administrate

Two delivery channels:

- Customized incentives
  For specific applications and all-system efficiency
- Rebates
  For large volume widgets

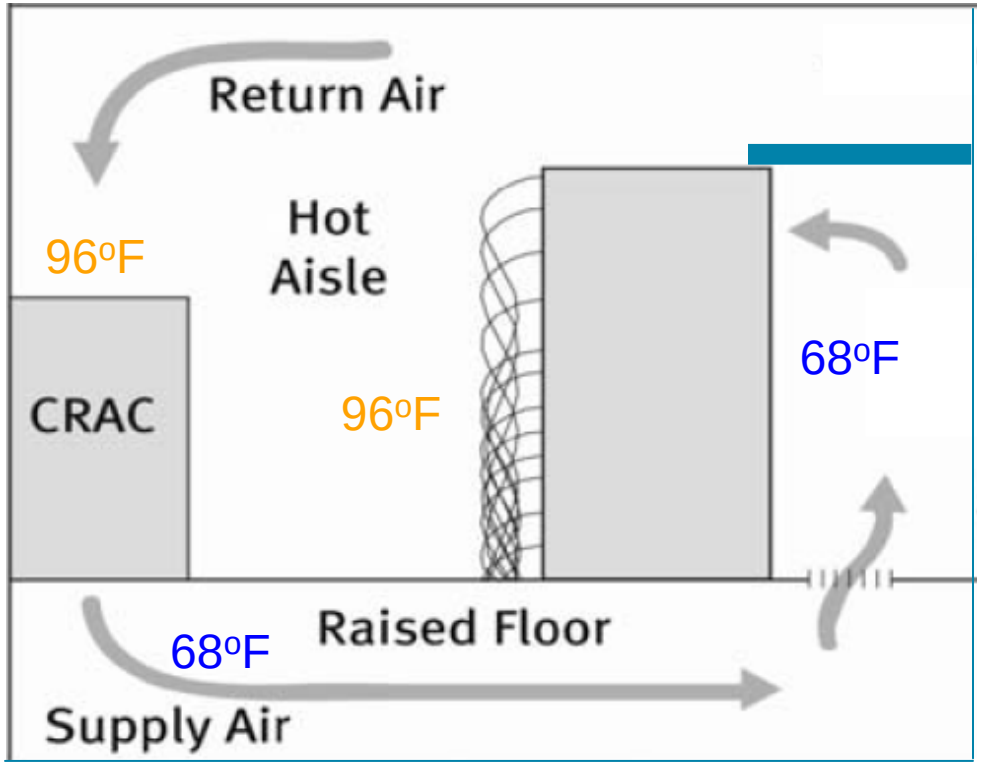
And free support services:

- Audits and Engineering assistance
- Information and training

How to evaluate the excess of supply air?

If there is no mixing:

- the server inlet temperature equals the supply temperature
- the return temperature equals the server outlet temperature

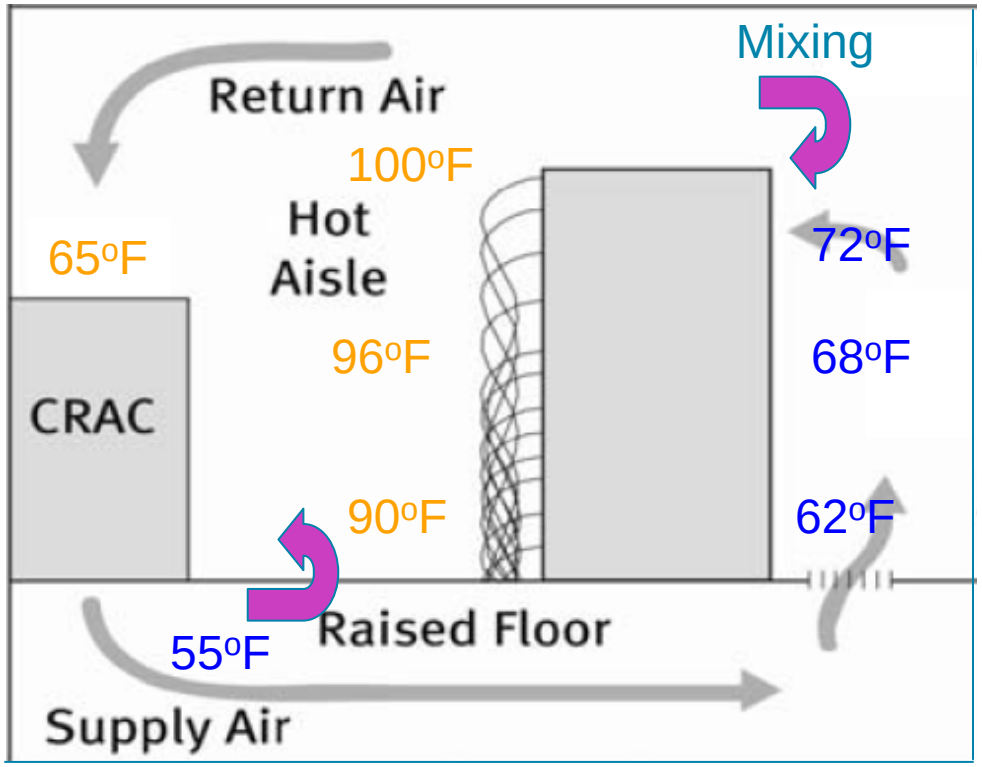


$$\Delta T_{CRAC} = \Delta T_{Servers} \; and \; \sum \dot{V}_{CRAC} = \sum \dot{V}_{Servers}$$

How to evaluate the excess of supply air?

If there is mixing:

- Cold air mixes with hot return air
- Hot air mixes with supply air
- excess of air is supplied to the Data Center



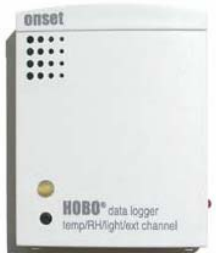
$$\sum \dot{V}_{CRAC} > \sum \dot{V}_{Servers} \text{ and } \Delta T_{CRAC} < \Delta T_{Servers}$$

A simple method to evaluate the air-flow efficiency

- Without latent heat exchange:

$$\sum\left(\dot{V}_{Servers}\cdot\Delta T_{Servers}\right)=\sum\left(\dot{V}_{CRAC}\cdot\Delta T_{CRAC}\right)$$

- If all servers have a similar $\Delta T_{Servers}$ then:

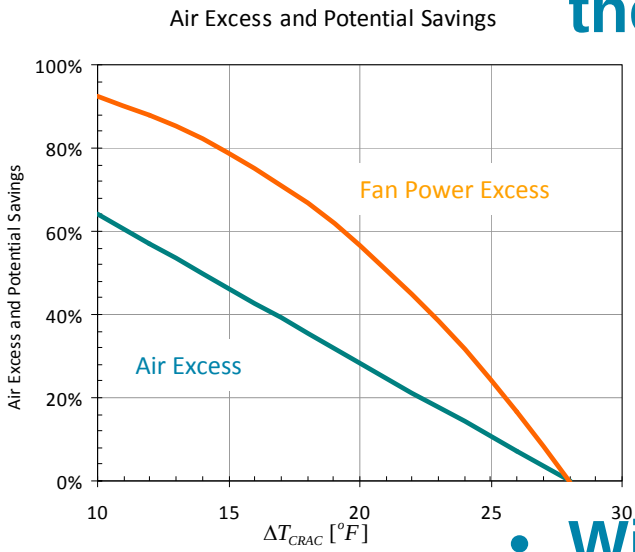


$$\frac{\dot{V}_{Excess}}{\dot{V}_{CRAC}}=\frac{\Delta T_{Servers}-\Delta T_{CRAC}}{\Delta T_{Servers}}$$

- By measuring ΔT_{CRAC} we can assess the excess of air supplied to the data center

CRAC Fan Saving Calculations

- **CRAC with VFD can be slowed down to the optimal air-flow, and savings are:**



$$Savings_{Fan} = \dot{W}_{Fan} \cdot \left[1 - \left(\frac{CFM_{Fan,Opt}}{CFM_{Fan}} \right)^{2.5} \right]$$

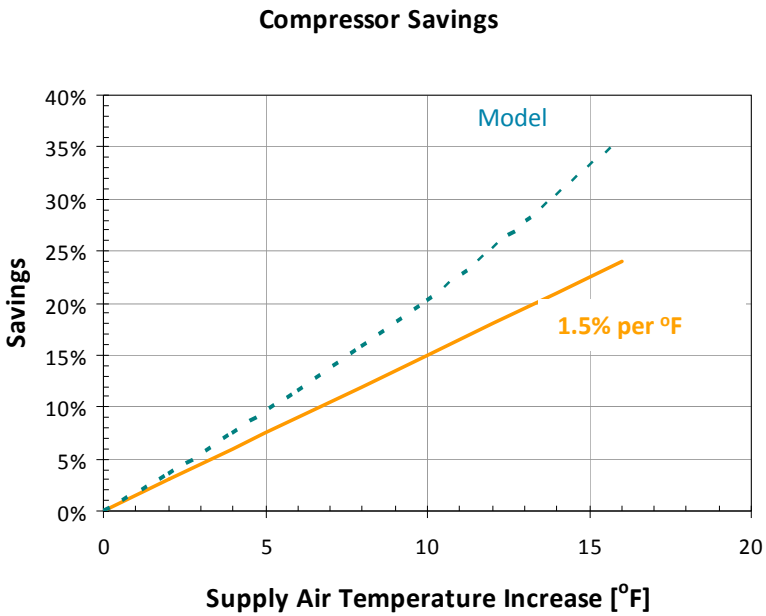
with

$$\dot{W}_{Fan} = \frac{CFM_{Fan}}{1{,}550} \quad [kW]$$

- **Without VFD, savings are captured by turning off CRACs to bring the overall air supply down to the optimal value.**

Compressor Saving Calculations

- **Because of more uniform temperature in cold aisle, supply air temperature may be increased.**
- **Savings are:**

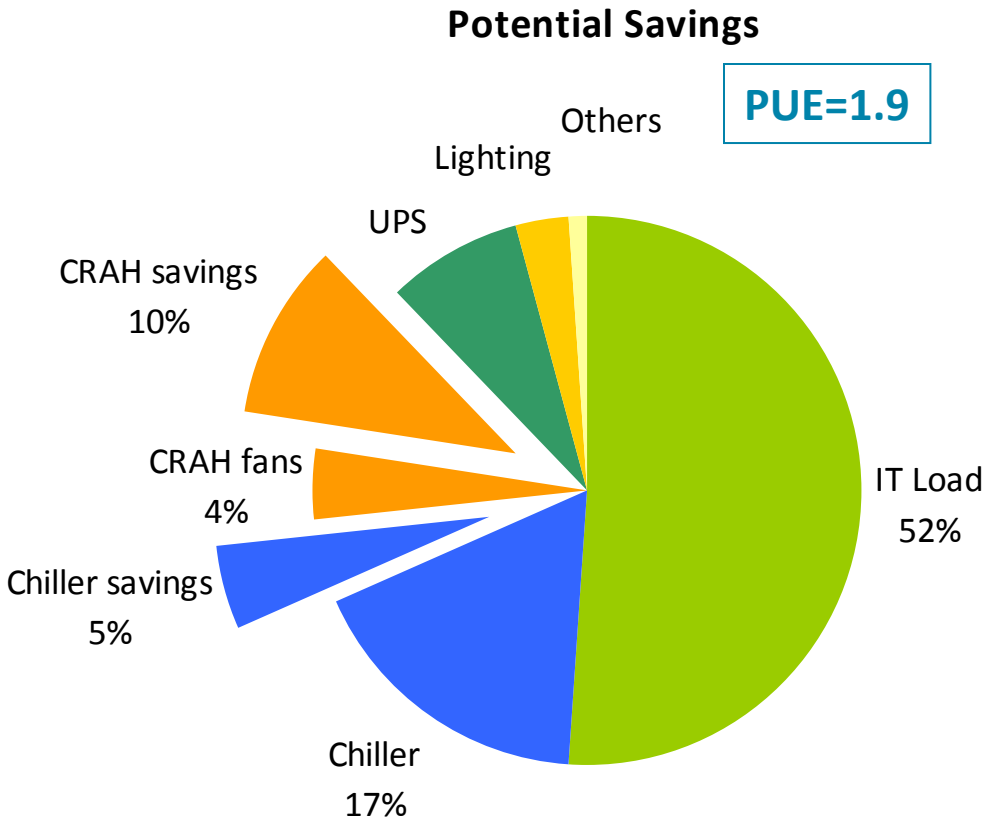


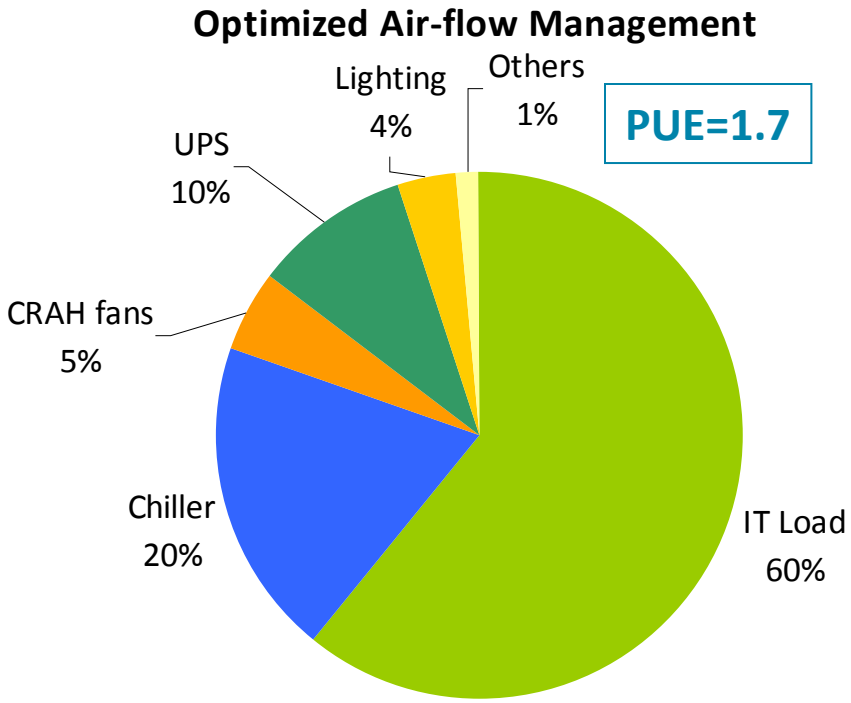
$$\Delta \dot{W}_{AC,Opt} = \dot{W}_{AC} \cdot 1.5\% \cdot \left(T_{SupplyOpt} - T_{Supply} \right)$$

with

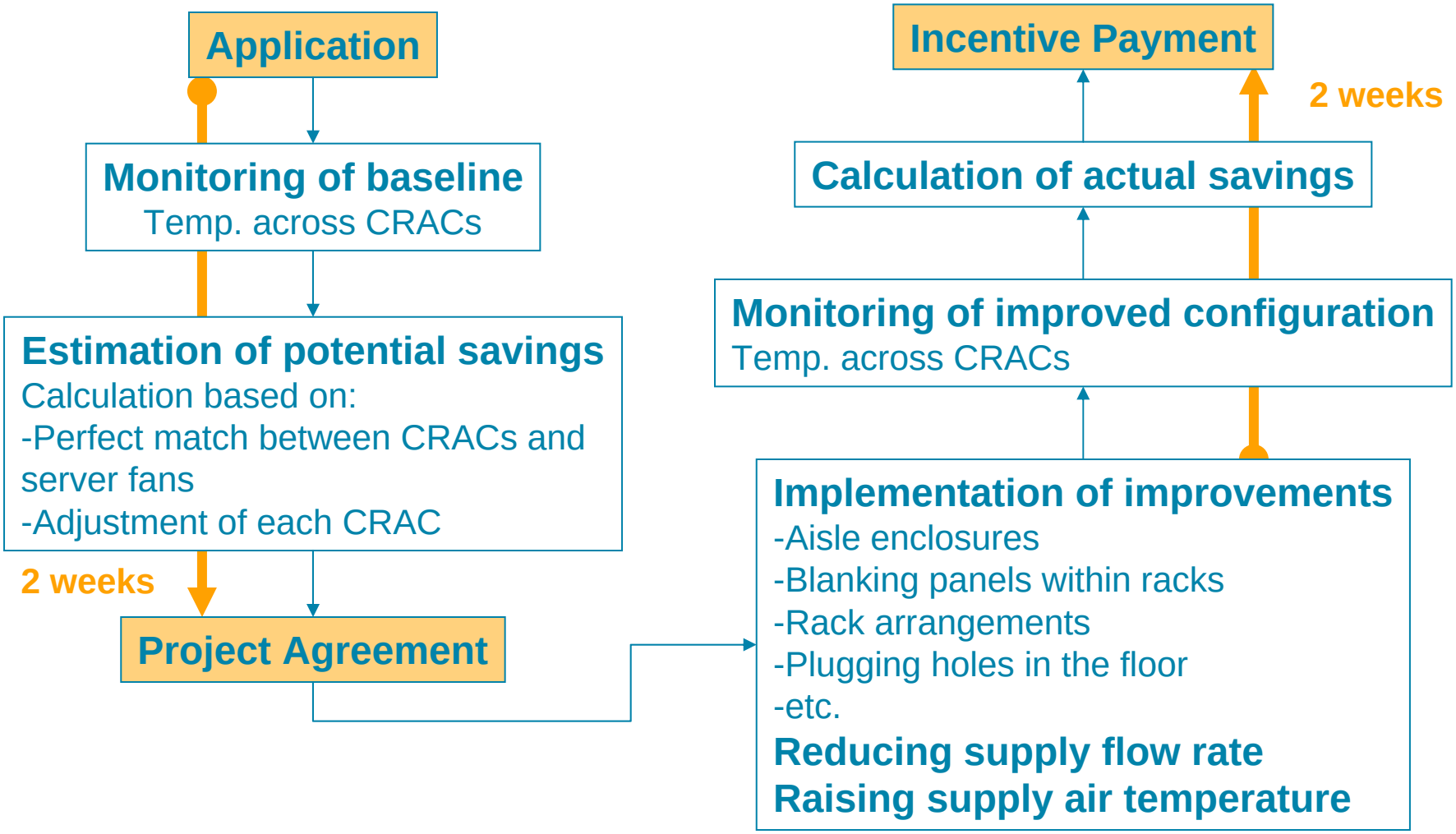
$$\dot{W}_{AC} = 1.0 \, {kW}/{ton} \cdot CoolingLoad[ton]$$

Example

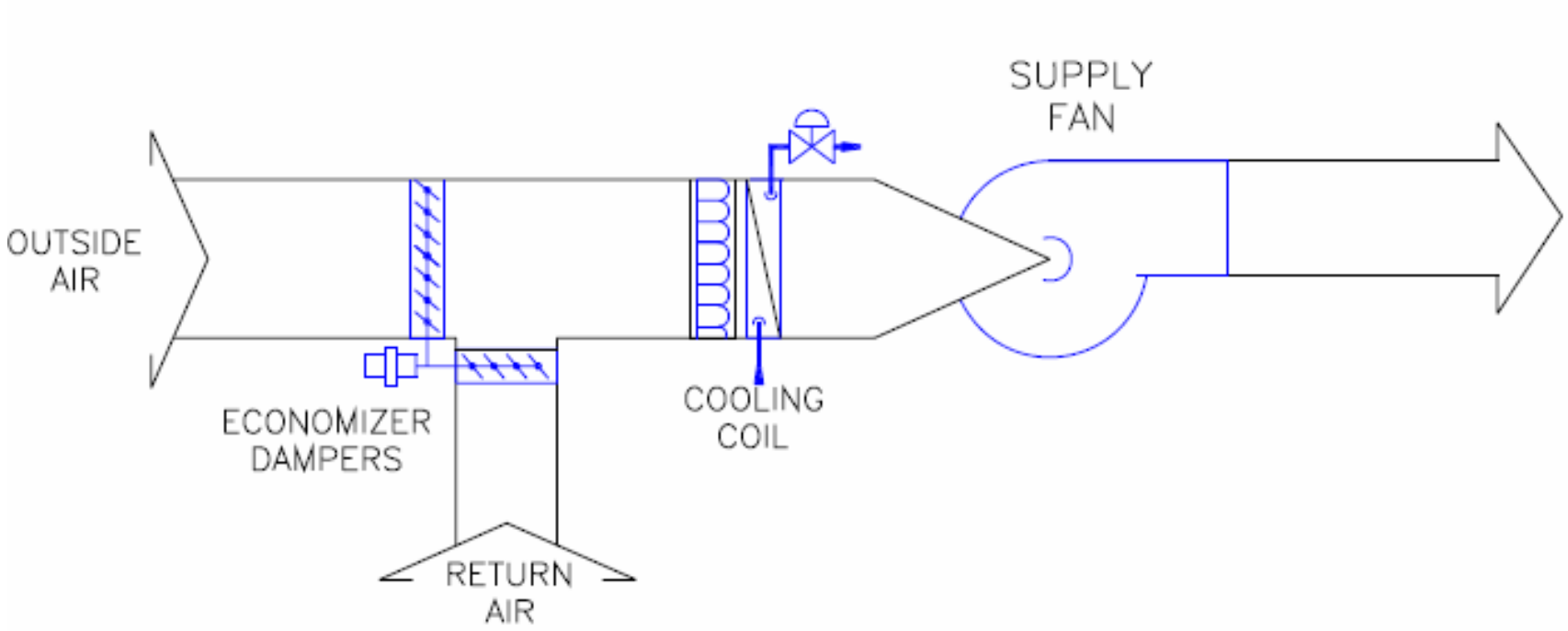

Potential Savings
PUE=1.9
Others
Lighting
UPS
CRAH savings
10%
CRAH fans
4%
Chiller savings
5%
IT Load
52%
Chiller
17%


Optimized Air-flow Management
Lighting
4%
Others
1%
PUE=1.7
UPS
10%
CRAH fans
5%
Chiller
20%
IT Load
60%

Process


Application
Monitoring of baseline
Temp. across CRACs
Estimation of potential savings
Calculation based on:
-Perfect match between CRACs and server fans
-Adjustment of each CRAC
2 weeks
Project Agreement
Implementation of improvements
-Aisle enclosures
-Blanking panels within racks
-Rack arrangements
-Plugging holes in the floor
-etc.
Reducing supply flow rate
Raising supply air temperature
Monitoring of improved configuration
Temp. across CRACs
Calculation of actual savings
2 weeks
Incentive Payment

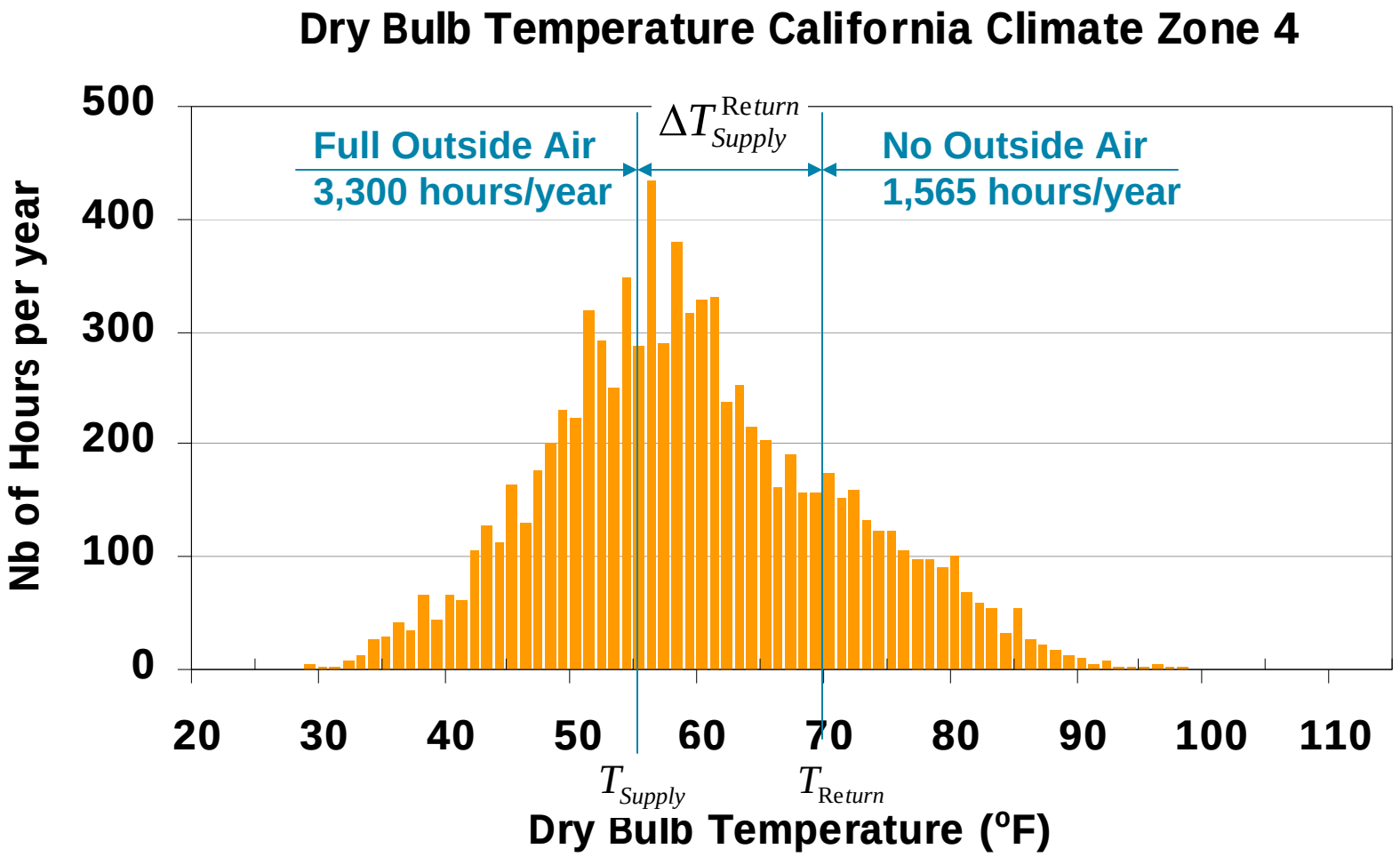
Outside Air-Economizer



Source: M. Hydeman HVAC and Control System Design for Improved Energy Performance in Data Centers
EPA Conference on Data Centers February 2006

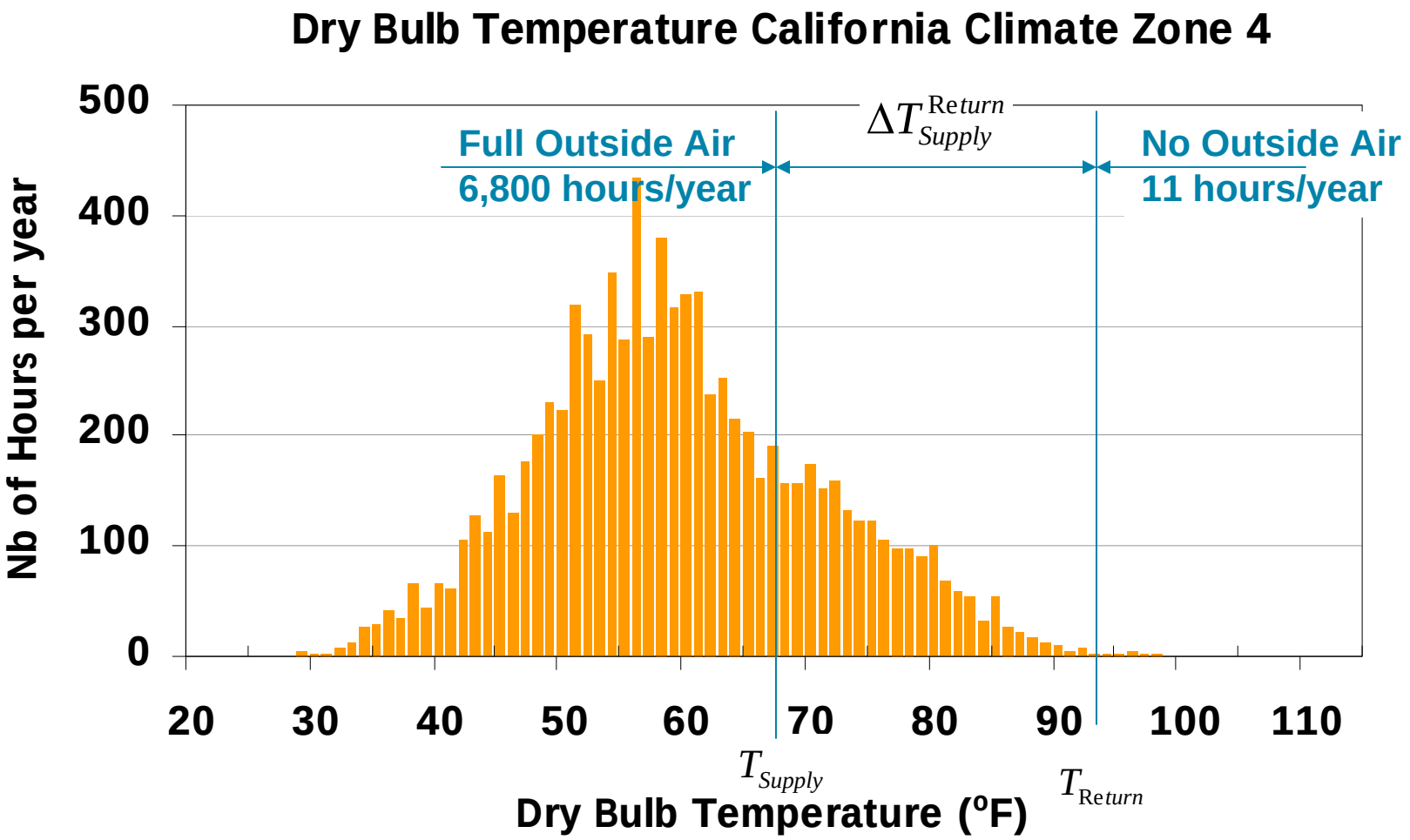
Outside Air-economizer

Before Air-flow optimization



Outside Air-economizer

After Air-flow optimization



Thank you!

Questions?