Case Study of A LEED Platinum Lab: Lessons From the Tahoe Center for Environmental Science

John Weale, P.E.

40,000 gross square feet

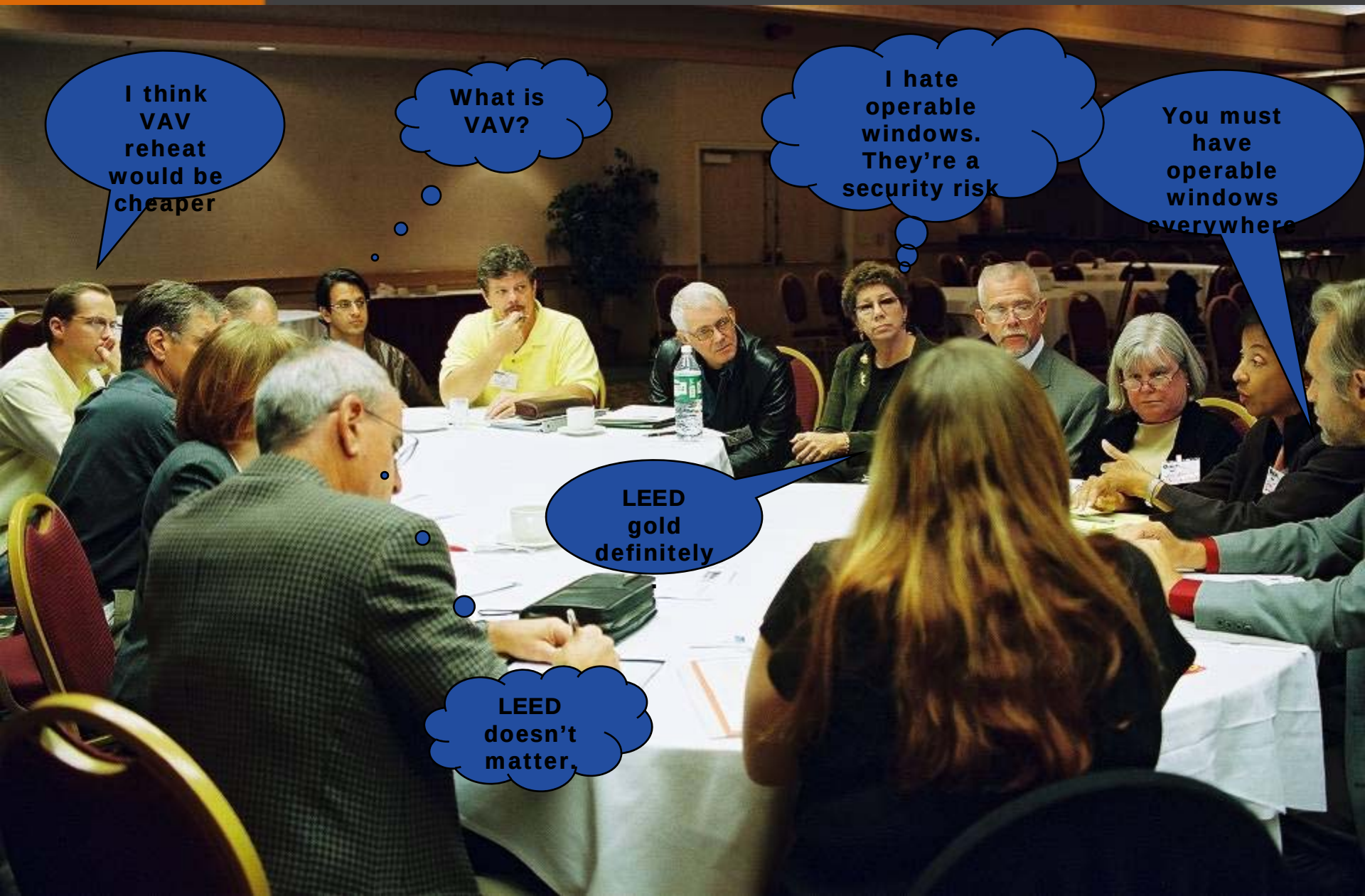
28% Teaching and Research Labs

LEED Platinum

The Players in the Programming

- Two Owners
  - Sierra Nevada College (and Board of Directors)
  - University of California Davis
- Local Architect – Lundahl Associates
- Other Consultants
  - Lab Consultant – RFD
  - LEED and Commissioning Consultant
  - Carnegie Mellon University
  - Labs 21
  - Peer review MEP Consultants
- Tahoe Regional Planning Agency (TRPA)
- General Contractor - Turner Construction
- Mechanical Contractor – RHP Mechanical

Educate and Set Direction Early



Some memorable quotes

- “Can you contact Prof. X in Germany to discuss the project”
- “Have you considered (i.e. you will use) the Solargenix system”
- “Why is there a chiller in the cost estimate”
- “This system is not going to work and will be ripped out right after it is installed”
- “The cogen system that we were going to donate is not appropriate for use in this building”
- At 25% CD “OK you can design the mechanical system as proposed”

Beware Too Many Options: Energy Options

Power Generation

- Vector Cogen (donation)
- Hess Microgen (donation)
- Capstone Turbine
- Reconditioned Capstone turbine
- Cogen heat recovery connection to dormatories
- Fuel Cell
- Woodchip gasification

Renewables

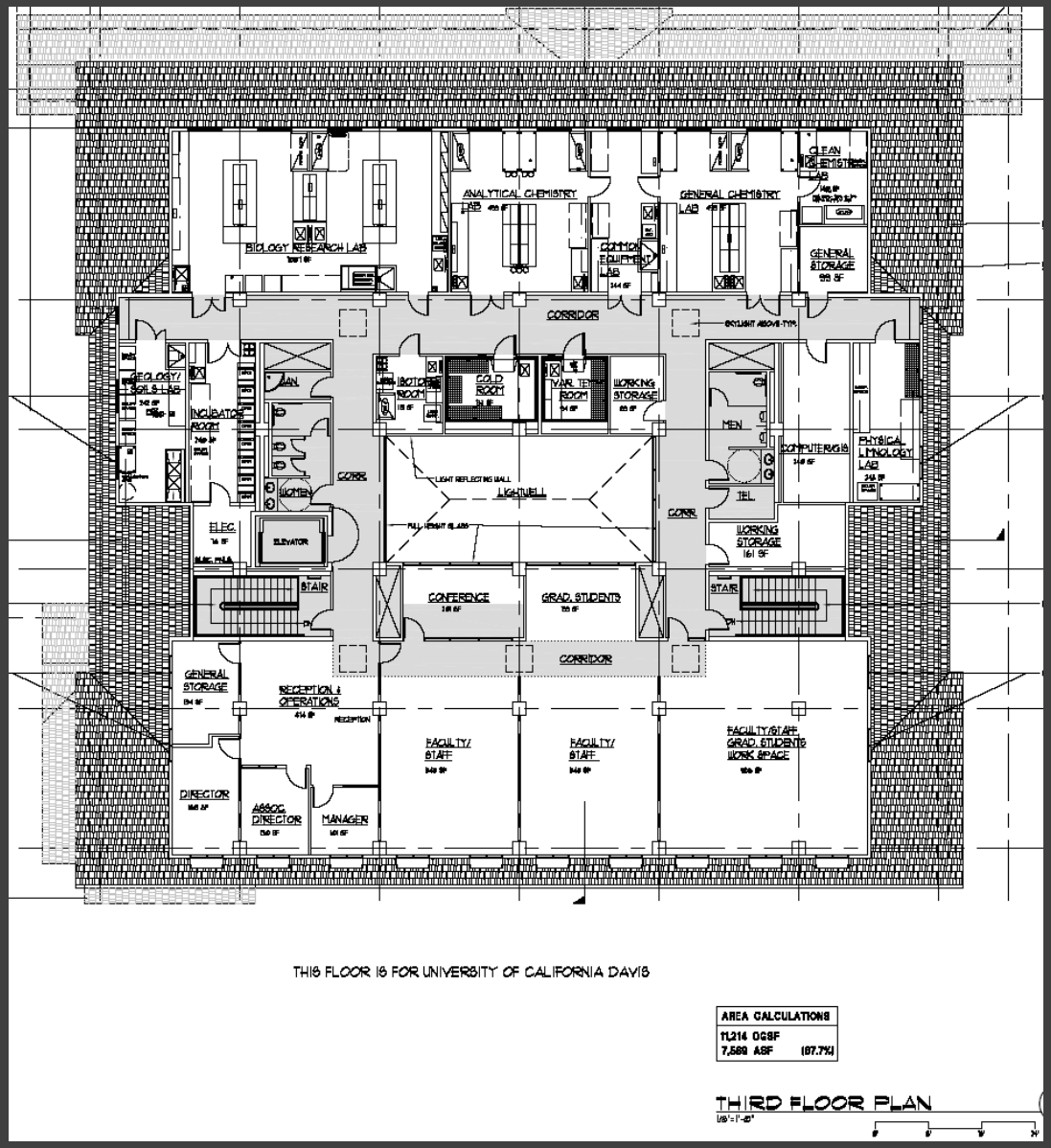
- Solar Genix Power Roof
- Photovoltaic Shingles
- Adhesive UNISolar PV modules
- Standard PV Modules
- Evacuated tube solar thermal
- Solar thermal panels

Cover the Standard Issues: Early Challenges

- Scoping of project - permitting & technologies before program
- Design team experience balance - selection of MEP team
- Consultant cooperation – integration
- Local authorities and regulations
  - Water district
  - Emissions questions
  - Aesthetic height limitations
- Memorable Quotes
  - "The environmental permit approval doesn't include an exhaust stack."
  - "The radiation shielding needed to achieve background levels is a single sheet of paper."

Define the Project: Zoning Basics - Project Goals

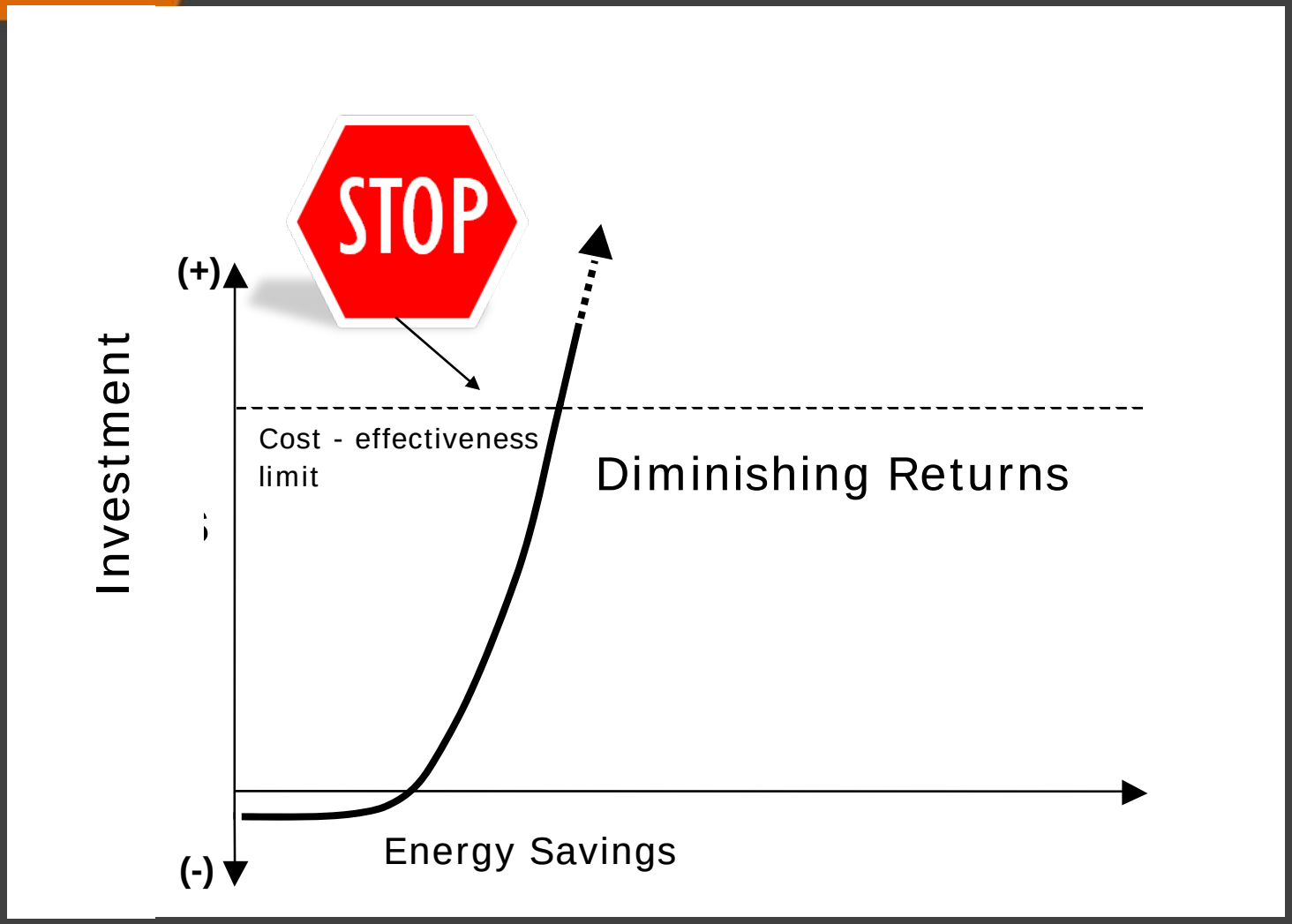
- Provide a program including multiple lab types
- Provide a state of the art research & teaching environment
- Provide a safe, healthy working environment
- Deliver on schedule and budget
- Incorporate replicable and cost effective sustainable strategies



Consider the Options: Pushing the Envelope

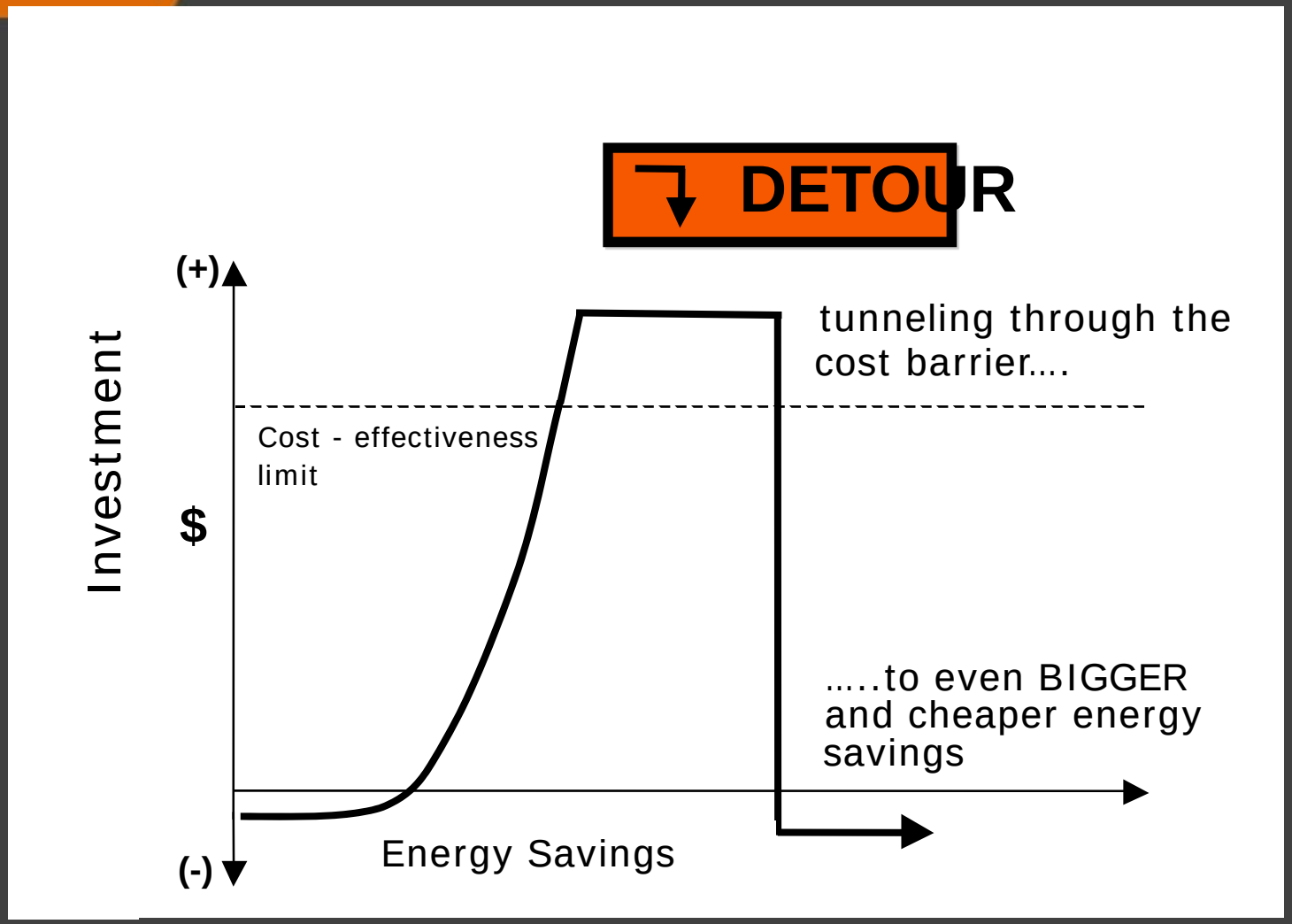
- Raised floors
- Natural Ventilation
- Efficient chillers
- Chilled water primary only variable flow pumping
- Variable flow condenser water
- Efficient cooling towers
- Thermafusers
- Dedicated OA Air Handlers
- Heat Recovery
- CO2 sensors - demand ventilation
- Low face velocity air handlers
- Free cooling - water side economizers
- Night time purge
- Radiant Heating and cooling
- Geothermal sources of heating and cooling
- Solar thermal
- Condensing boilers
- Better design….
- Etc., etc. etc.

The Cost Barrier…



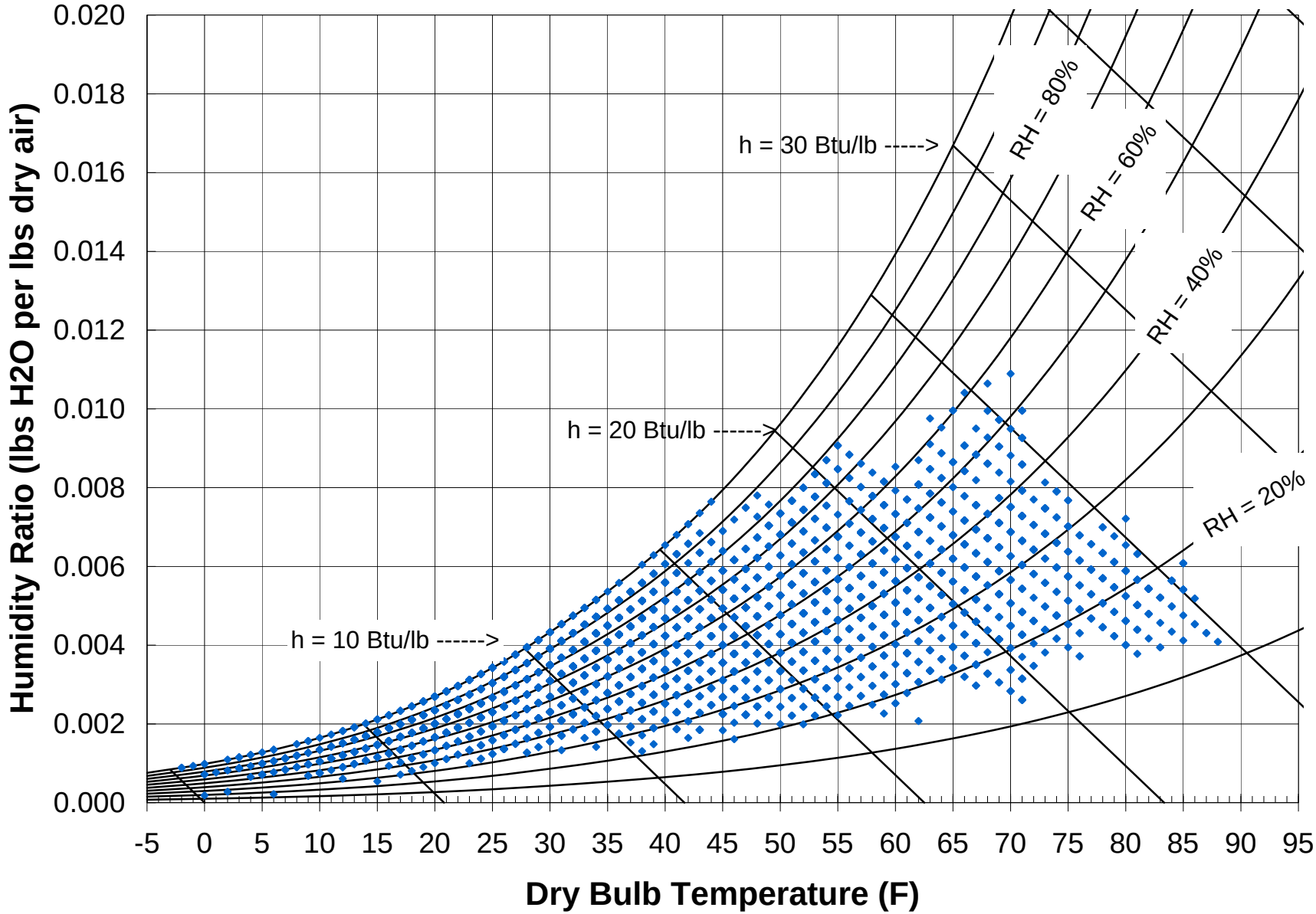
Natural Capitalism, Hawken, Lovins, Lovins.

Tunnel Through the Cost Barrier…



Natural Capitalism, Hawken, Lovins, Lovins.

Use the Climate, Don't Just Fight it: Weather Data



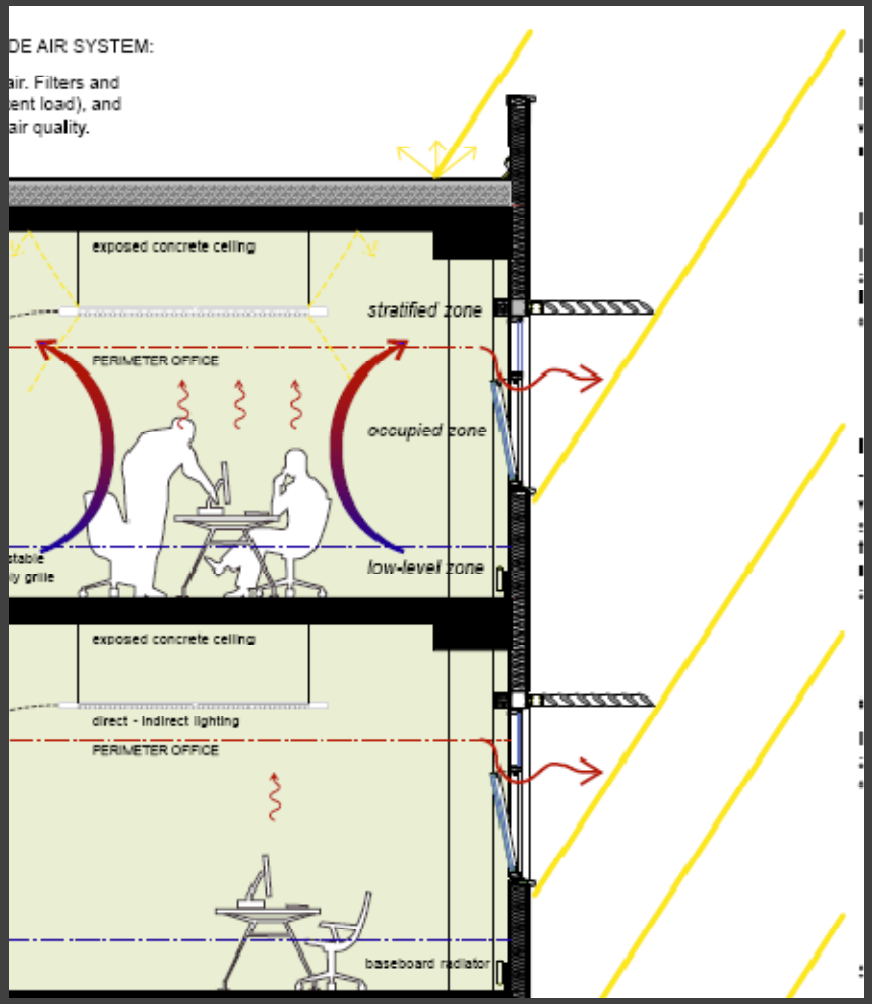
evapco

Design for Peak Load Capacity AND Typical Load Efficiency

Cost Estimates are Hard:
Garbage in = Garbage out
Time and Effort in = Cost Optimization Out

- Cost drives design, but estimate often inaccurate for innovative designs
- Original cost quote included
  - A chiller (none was in the design)
  - 70,000 pounds of ductwork (37,000 was required)
  - No square footage benefits
- Design team must review costs closely!

Daylighting – Lower loads



Lighting – It's about details

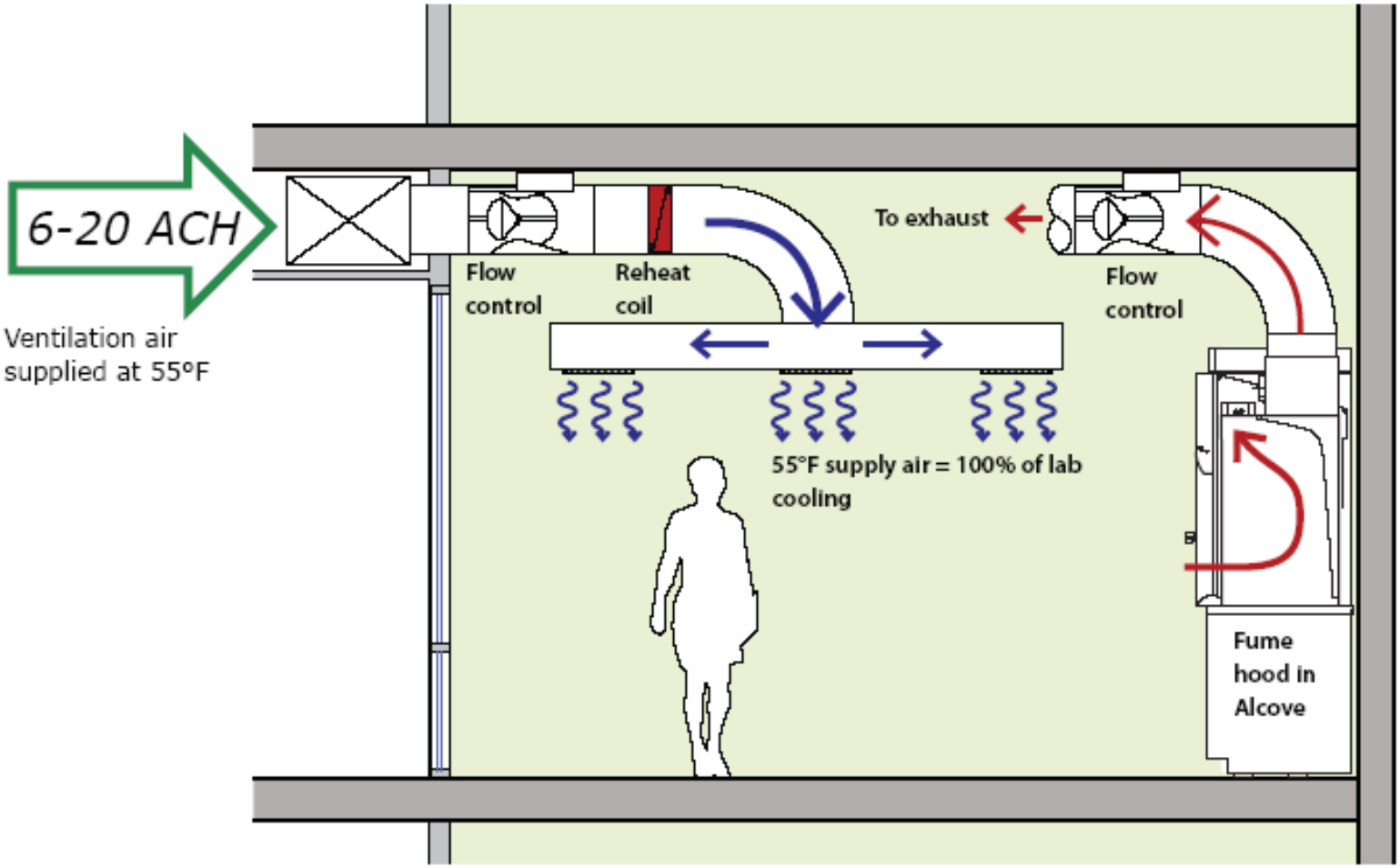
- 3rd floor UCD
  - 2 x 16' pendant rows
  - Pull lab benches back from exterior wall in order to increase window area
  - Add selective transmittance shade 10%
- 2nd floor teaching
  - Add east facing high glass to physical environmental science lab/classroom
  - Manual shades w/ 10% block out
  - 50 fc minimum ambient – contrast?
  - Task lighting on perimeter benches
  - White board light
  - Indirect pendant
  - Lights on top of of shelving [illegible]
  - Occupancy sensors –occu[illegible]or and off two s[illegible]sors [illegible]
- Task lighting
  - [illegible] - CFL
  - [illegible] fixture, [illegible] mount[illegible] [illegible]erneat[illegible] lab s[illegible]f, [illegible]cul[illegible]g [illegible] rail system
  - [illegible] rea[illegible] s[illegible], pos[illegible]ble [illegible]ti[illegible]lating [illegible] [illegible]d utility system
- Mo[illegible] [illegible] 2 lam[illegible] [illegible]
- L[illegible] su[illegible] – Surf[illegible] [illegible]ctanc[illegible] [illegible]spa[illegible] nothing less than 50%
- Lig[illegible]g con[illegible]ols – o[illegible]cu[illegible]y sen[illegible], manual on / auto off, no daylight sensors, zone for outside zone close to windows
- Nee[illegible] to ha[illegible] discu[illegible]sion [illegible]th lab consultant

35% BELOW 90.1

Photos by Jeff Dow

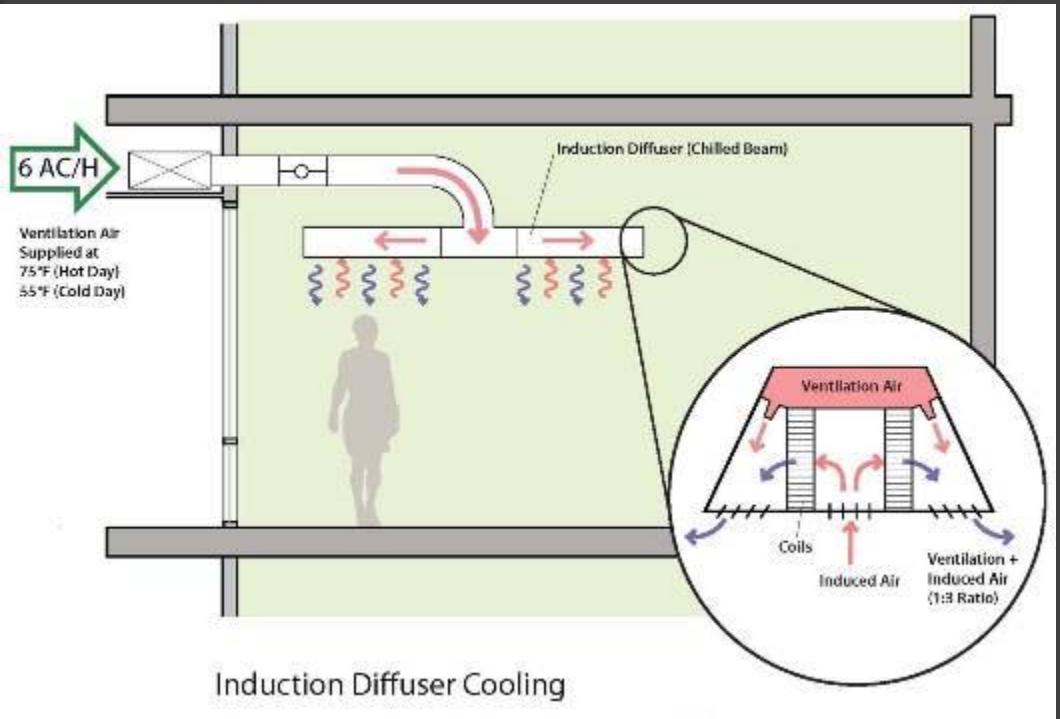
Design for Safety, Not Rules of Thumb: Air Changes

Standard Lab VAV System



Lab Chilled Beams

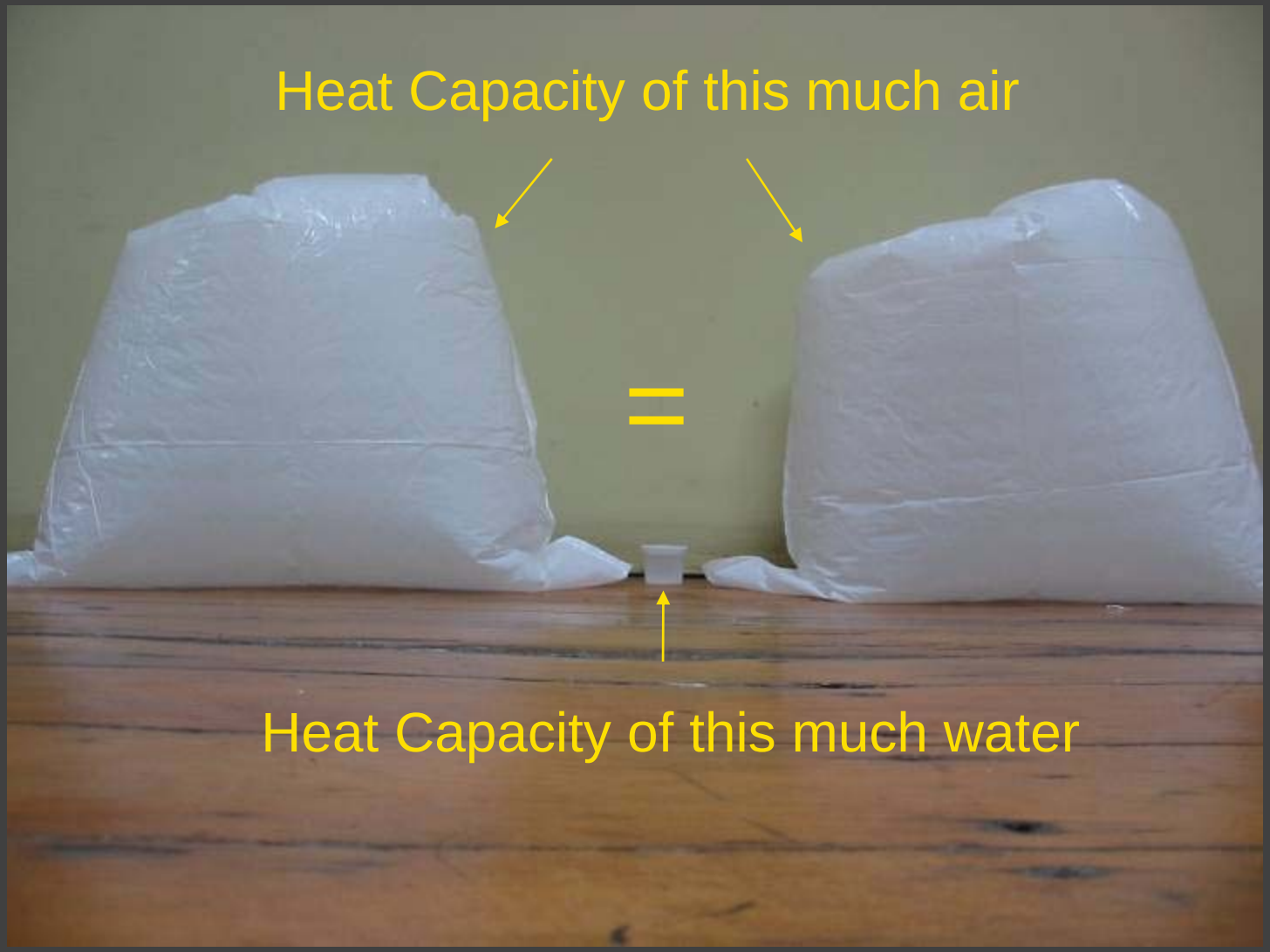
- NO Reheat in labs
- NO Increased outside air to handle cooling load



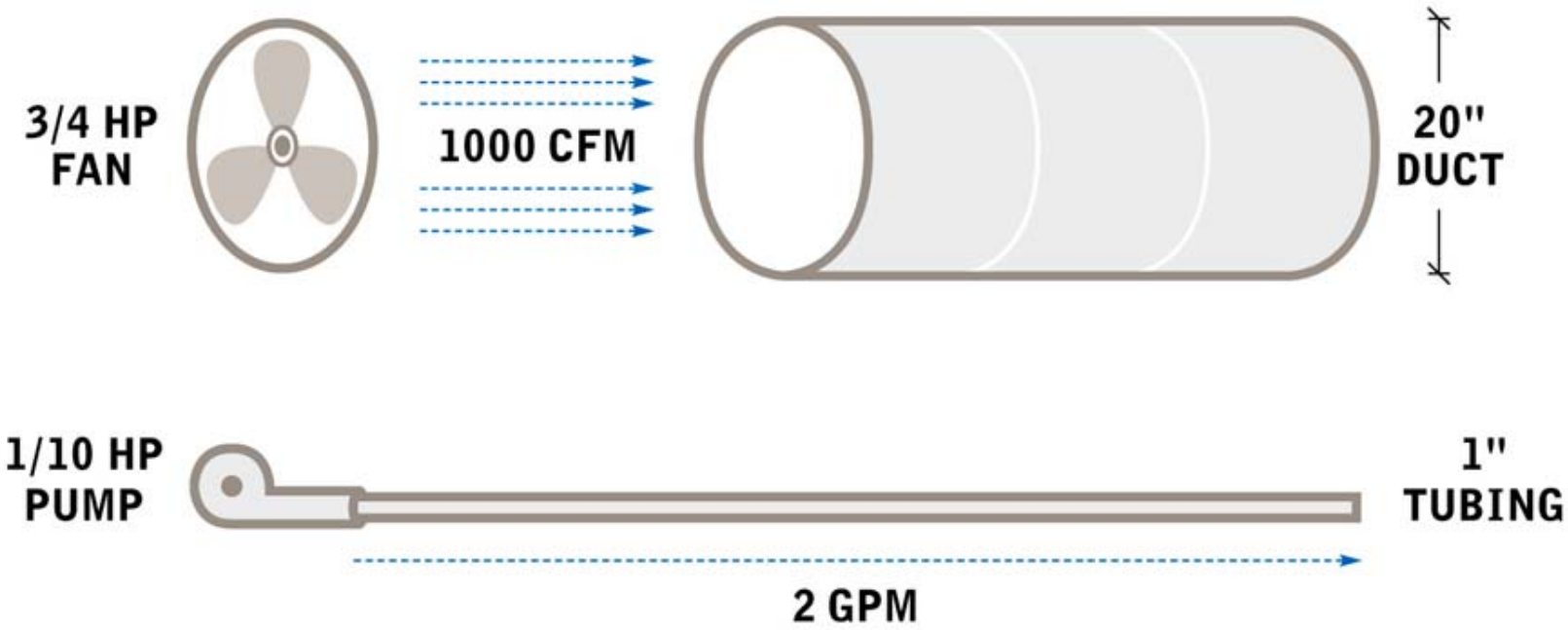
PRINCIPLES - Energy Efficient HVAC

- Lower the Loads First
- Right Size
- Use Simple Victorian Engineering to come up with elegant and efficient design
- Use passive sources for heating, cooling and ventilation
- Select more efficient equipment
- Use controls where appropriate

Why Condition with Water Not Air?

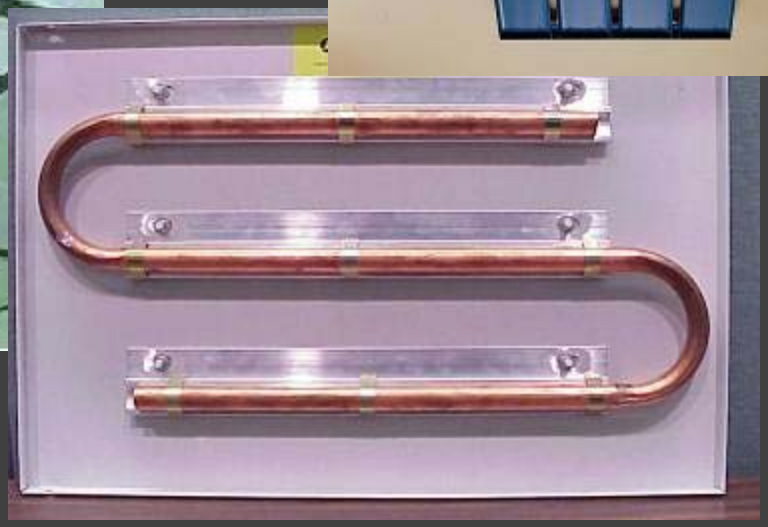


Smaller and Lower Energy

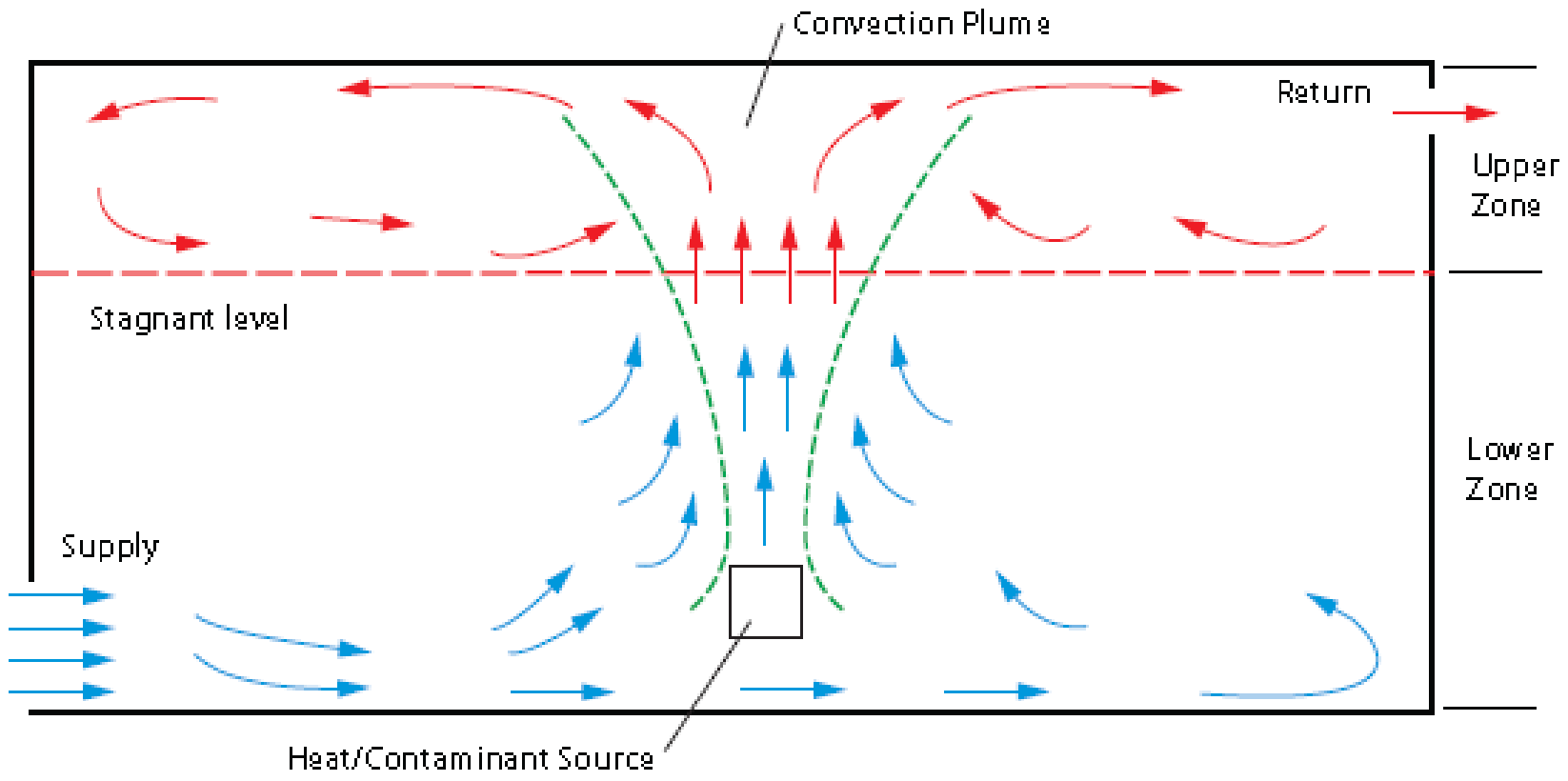


Why Does Design Load Matter?

- A variety of radiant panels are available – hung or integrated

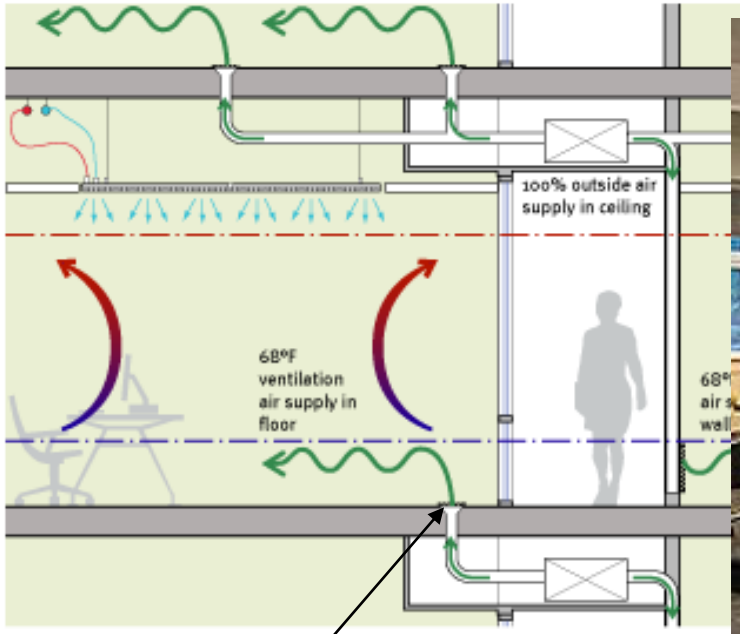


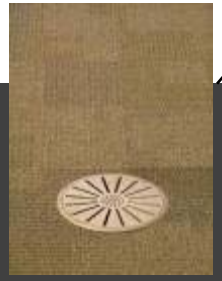
Displacement Convection Plume



radiant cooling + heating

section through typical office





LOW PRESSURE DROP SYSTEMS

Low Face Velocity = Low Pressure Drop

$$\text{Face Velocity} = \frac{\text{Unit CFM}}{\text{Coil or Filter Face Area}}$$

Coil Sizes for 43,000 CFM Air Handler

500 fpm	425 fpm	350 fpm	300 fpm
87 sf	102 sf	124 sf	145 sf
9.3’ square	10.1’ square	11.1’ square	12’ square

Lab Pressure Drop – Case Study, Supply

	Typical	TCES – UC Davis
Air handling unit – Clean filters including system effect	2.2” w.g.	0.68” w.g.
Dirty Filter Allowance	1.3” w.g.	1.45” w.g.
Heat Recovery	0.5” w.g.	0.56” w.g.
Silencer	1.0” w.g.	0
Supply Duct Work, Diffusers	2.5” w.g.	0.65” w.g.
VAV device	0.5” w.g.	0.30” w.g.
Zone coils	0.4” w.g.	0.20” w.g.
Safety Factor	0.6” w.g.	0.60” w.g.
Total Supply	9.0” w.g.	4.4” w.g.

Lab Pressure Drop – Case Study, Exhaust

	Typical	TCES – UC Davis
Hood	0.50” w.g.	0.50” w.g.
Flow Device	0.45” w.g.	0.30” w.g.
Exhaust Duct Work	2.00” w.g.	0.55” w.g.
Heat Recovery with filter	0.50” w.g.	0.50” w.g.
Exhaust Outlet (incl. velocity pressure)	0.70” w.g.	0.70” w.g.
Total Exhaust	4.15” w.g.	2.55” w.g.
Total Static Supply plus Exhaust	13.15” w.g.	6.95” w.g.

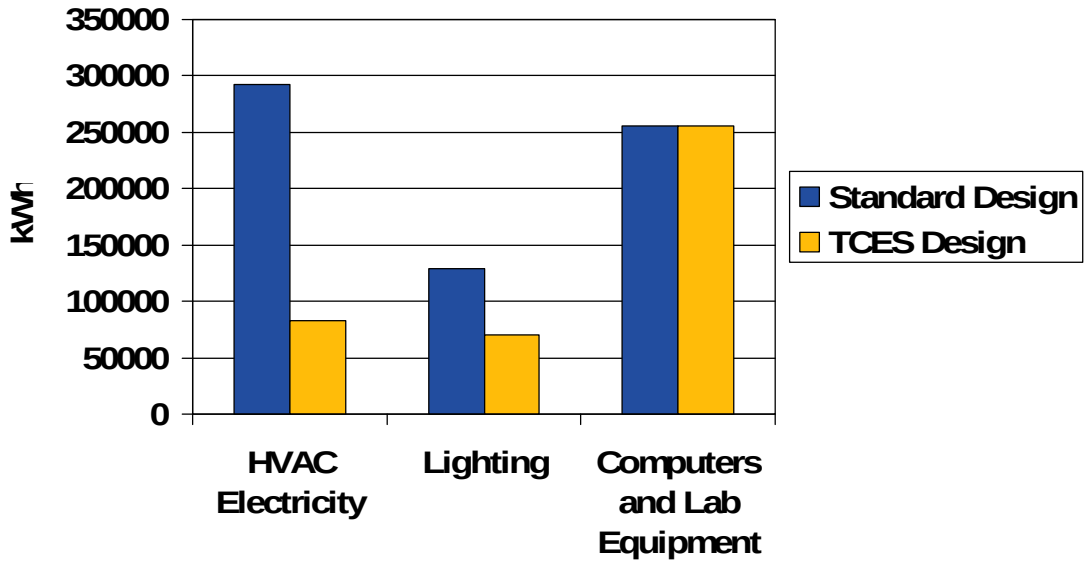
Air Handler Results

- Calculated Standard Reheat Type Air Handling
  - 32,500 CFM
  - 9.0” Supply Pressure Drop
  - 500 fpm coils
  - **61.9 Brake Horse Power (bhp) Fan**
  - **AHU Foot Print – 25’ by 11’**
  - **AHU W/cfm – 1.4**

- TCES Selected Air Handler
  - 18,000 CFM
  - 4.4” Supply Pressure Drop
  - 300 fpm coils
  - **17.3 Brake Horse Power (bhp) Fan**
  - **AHU Footprint – 21’ x 10’**
  - **AHU W/cfm – 0.72**

Results

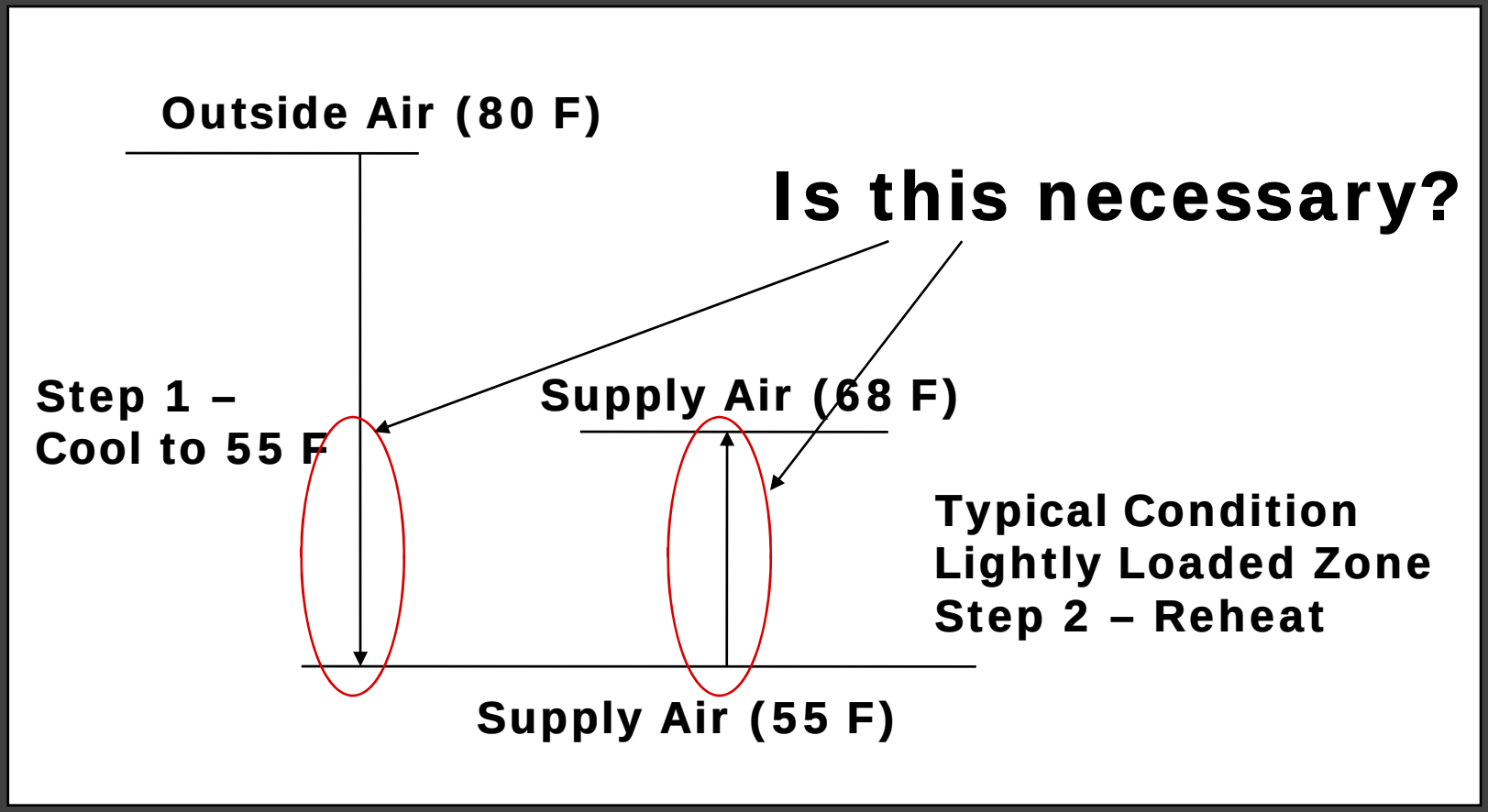
Smaller Air Handler, Lower Construction Cost



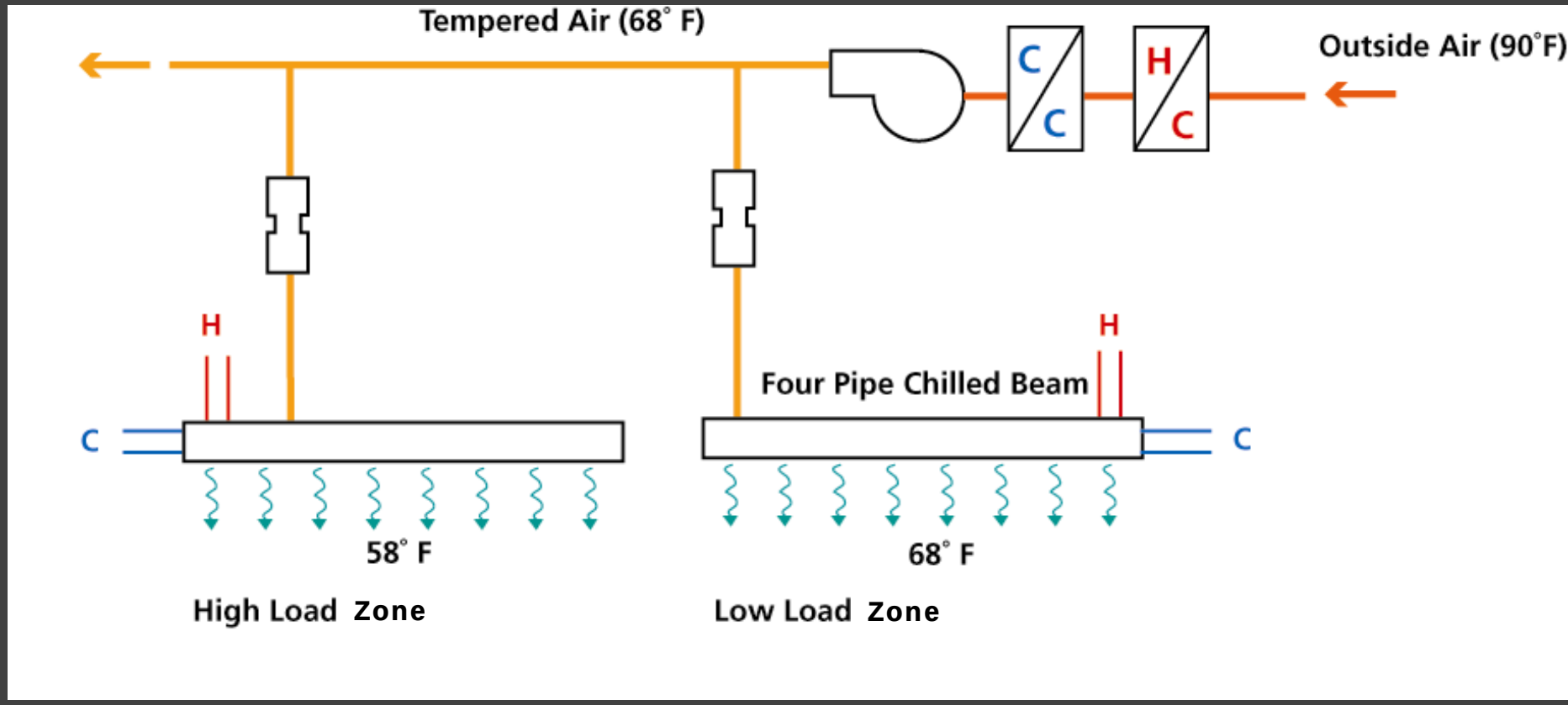
60 % Overall Energy Cost Savings

ELIMINATION OF REHEAT

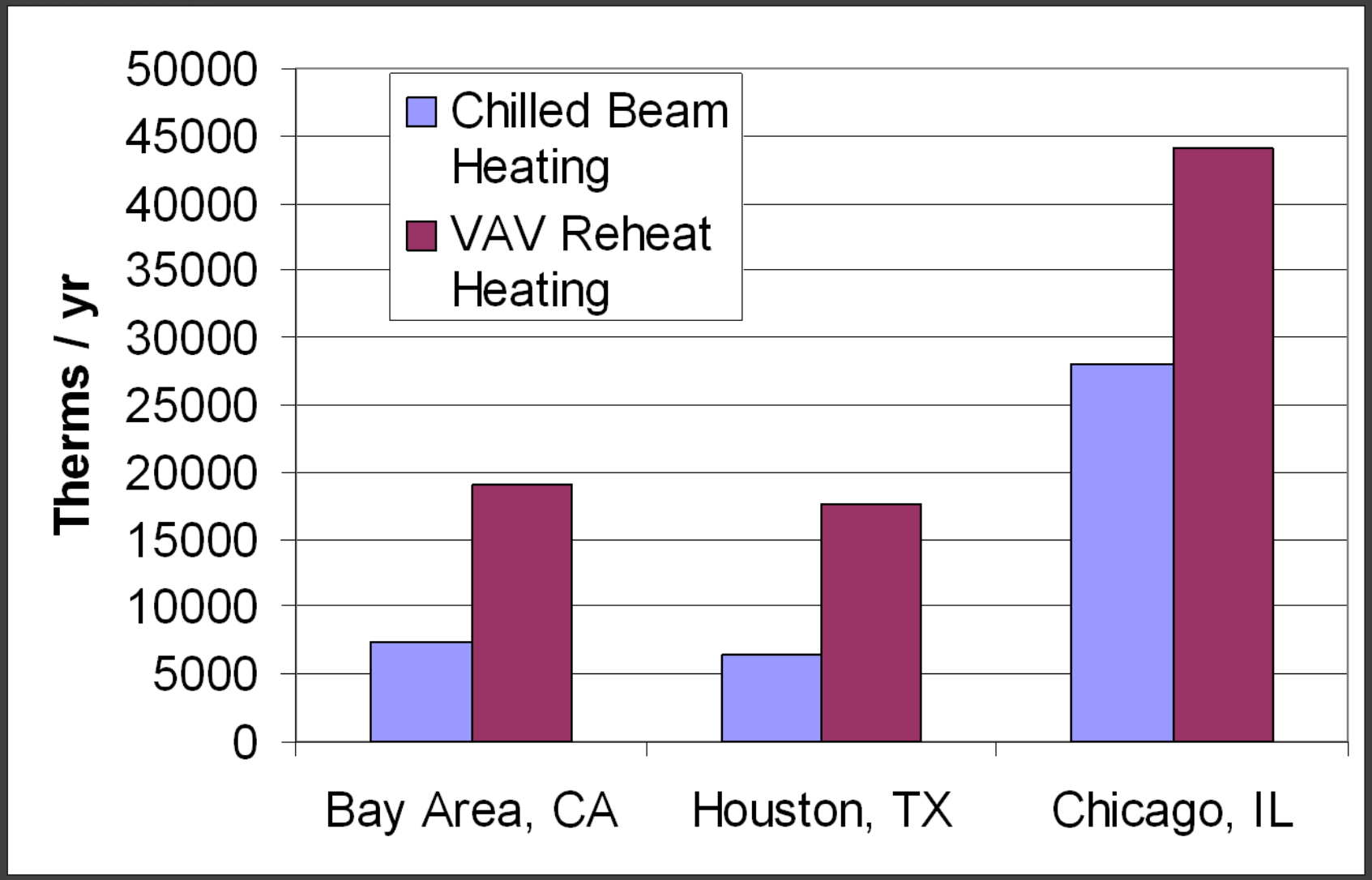
Typical Reheat Cooling System



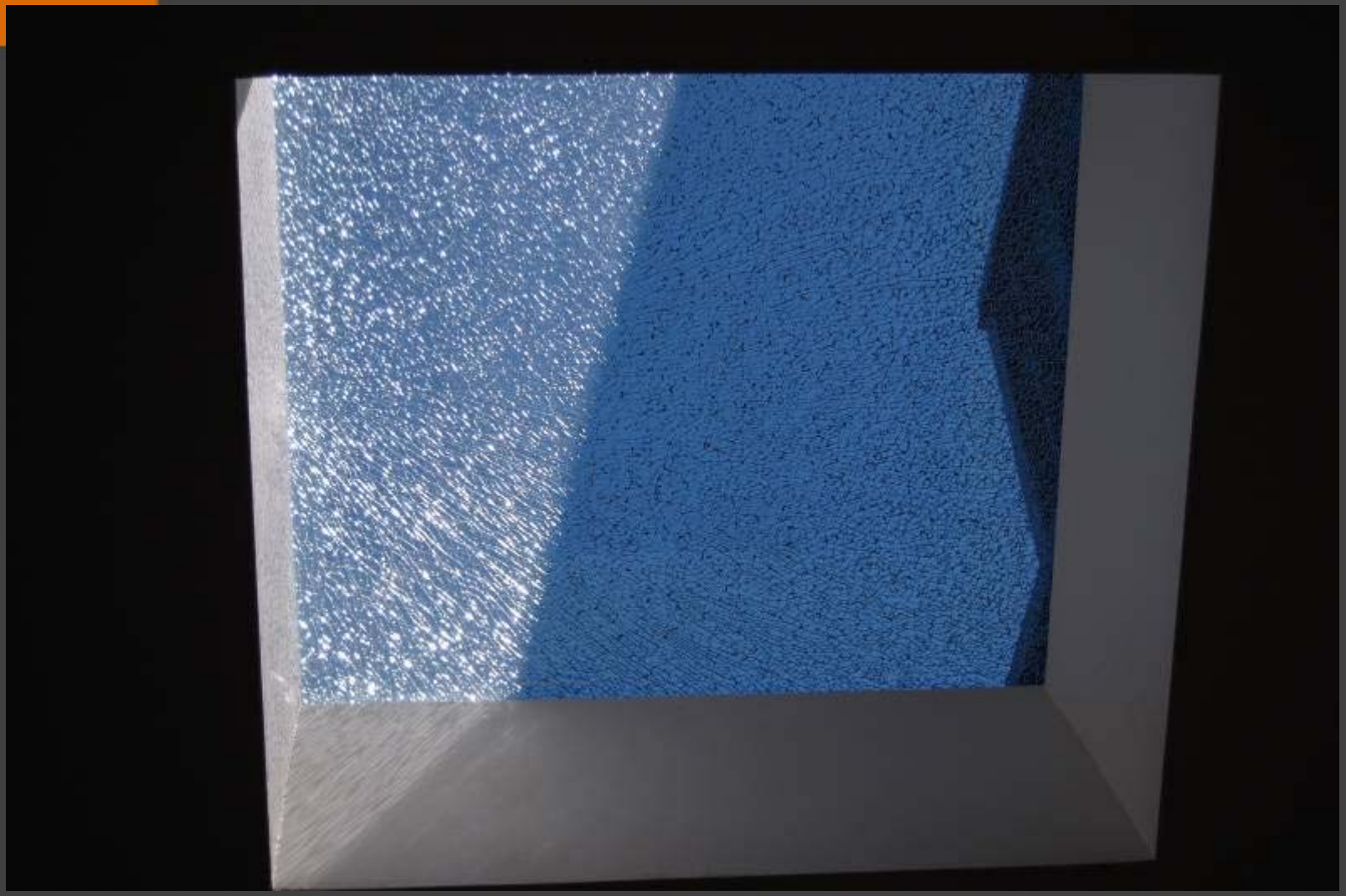
One Optimization Option: Chilled Beams (Four Pipe Induction)



Chilled Beam, Heating Energy Reduction



Commissioning: NOT just a punch list



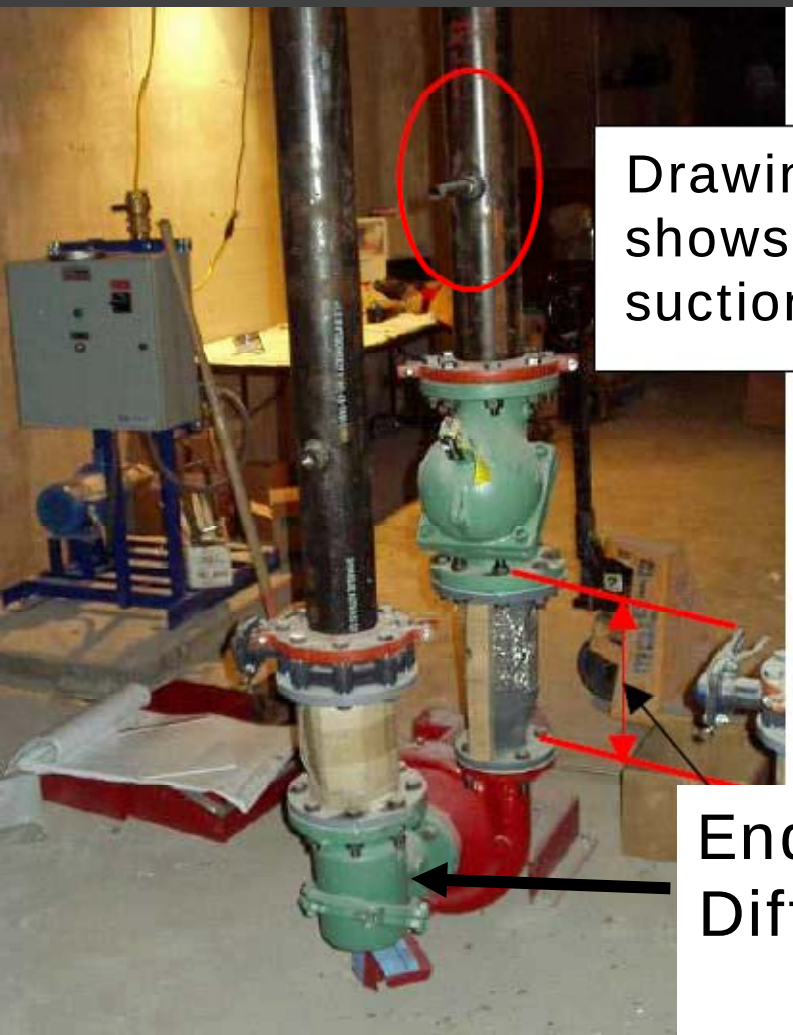
Construction Challenges

Kinked flex duct at induction diffuser

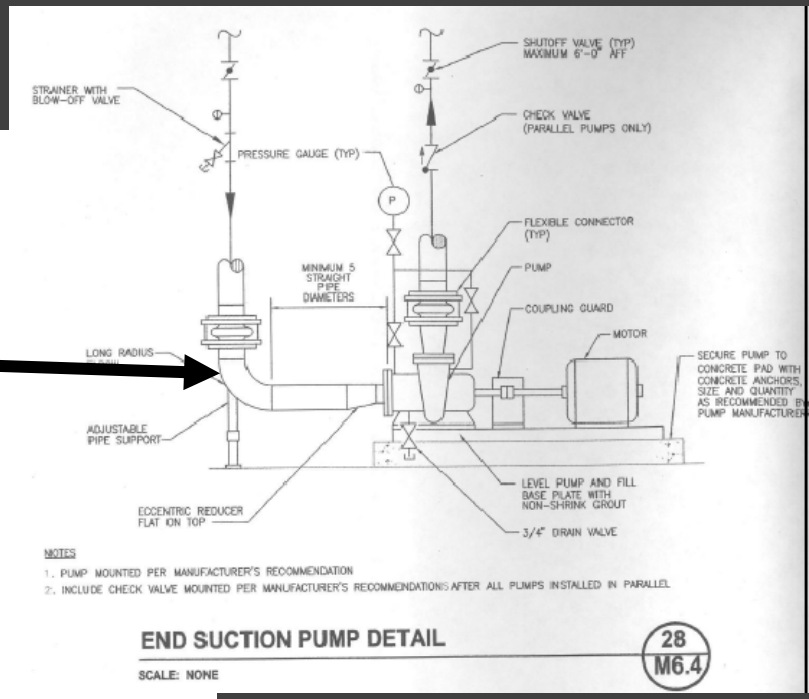
Blocked access to lab air valve

Lack of exhaust duct sealant

Even Good Design Doesn't insure good construction



Drawing clearly shows no end suction diffuser



End Suction Diffuser

Process Lessons Learned

- Creating justification for and filtering options for innovative design takes extra time – best spent in SD
- Extra effort is required on SD cost estimate
- Get commitment to system concept no later than end of SD
- Sustainable design doesn't happen if the key players aren't on board
- Identify opportunities to tunnel through cost barrier

Technical Lessons Learned

- Filter pollen from rain water
- Trust the analysis
- Orient chilled beams perpendicular to fume hoods
- Devote extra time to submittal review and site visits
- Verify actual energy usage versus modeled.
- Equipment load estimate is too high unless based on measured data.

Thank You

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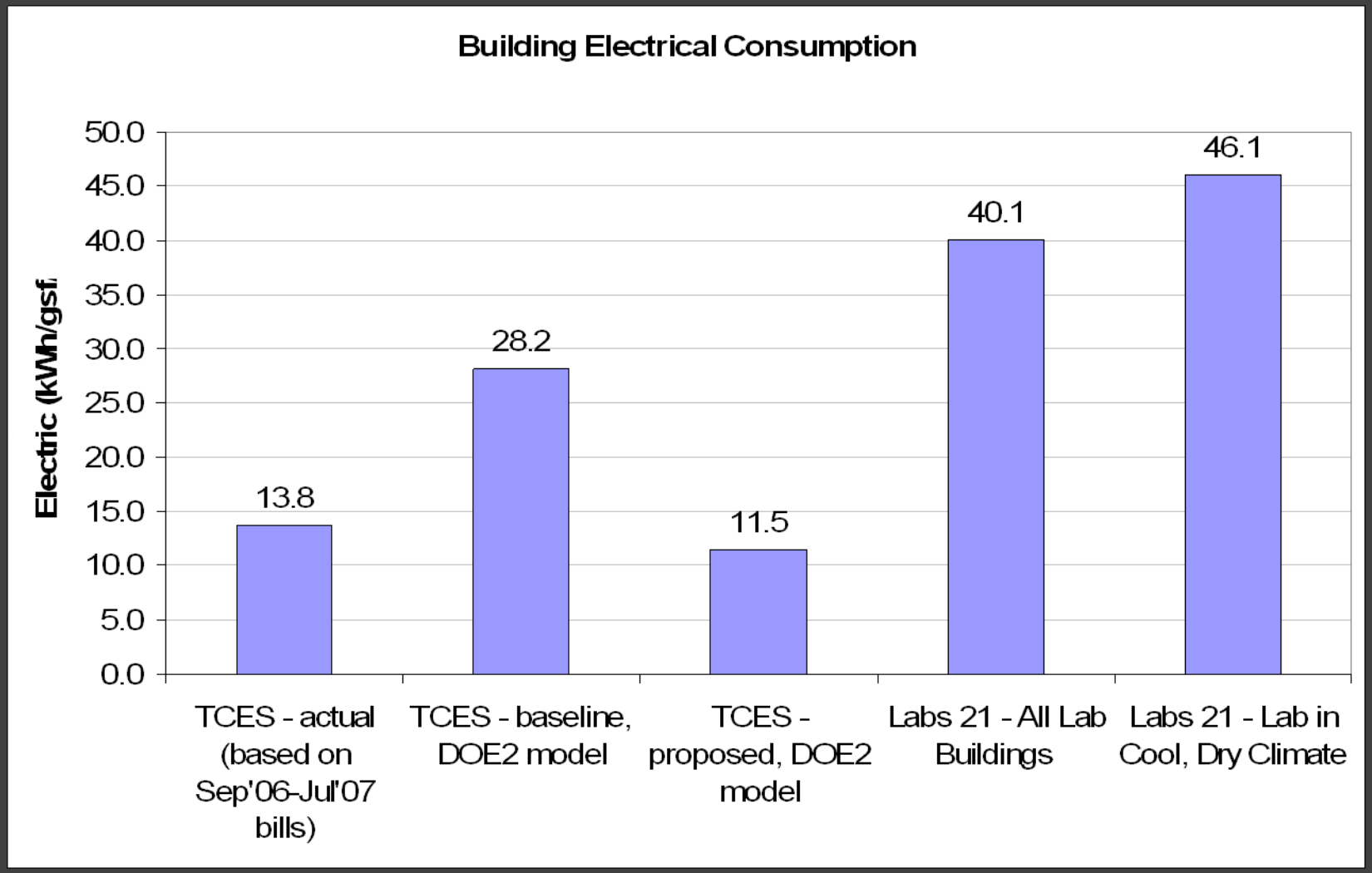
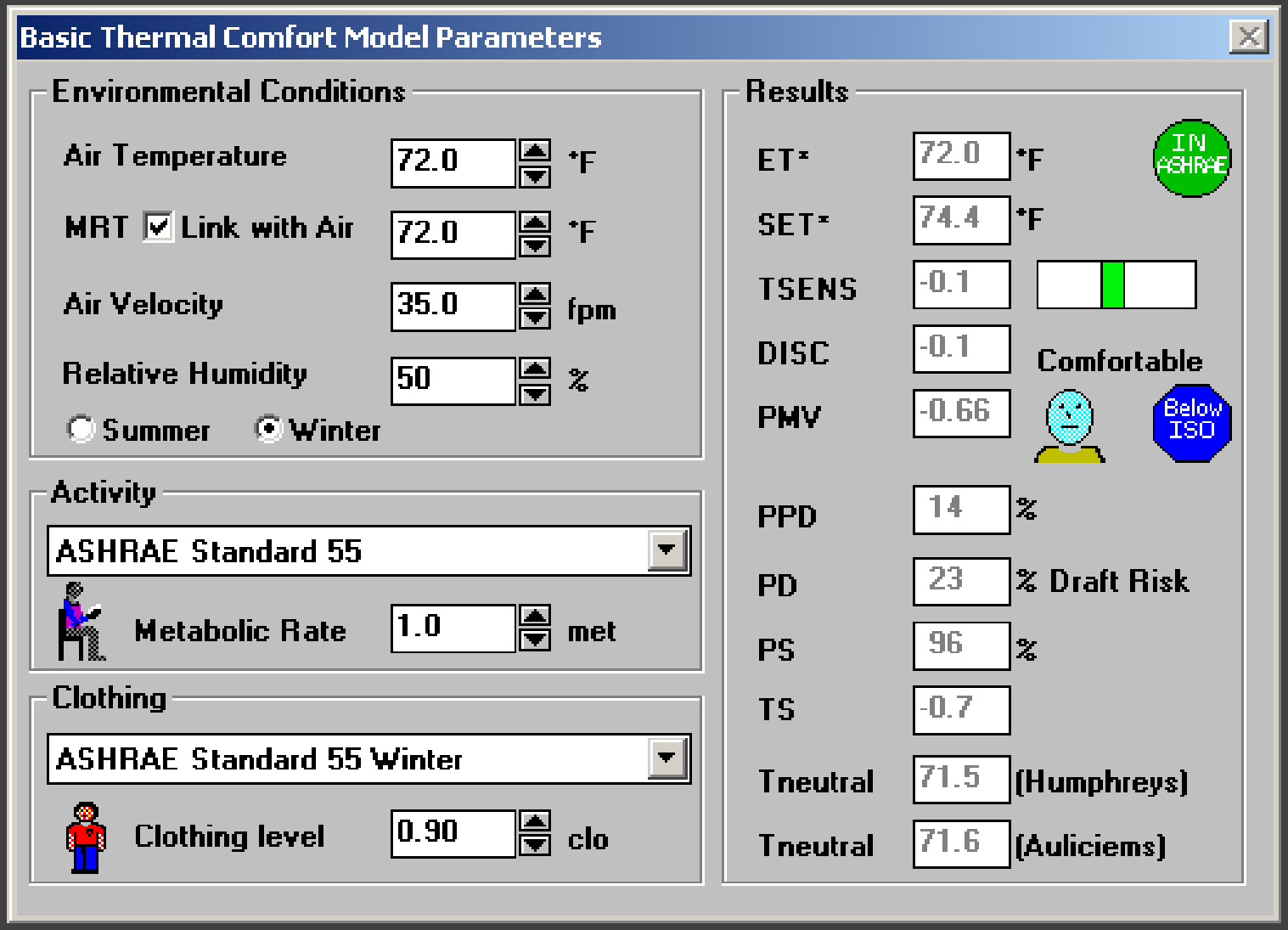
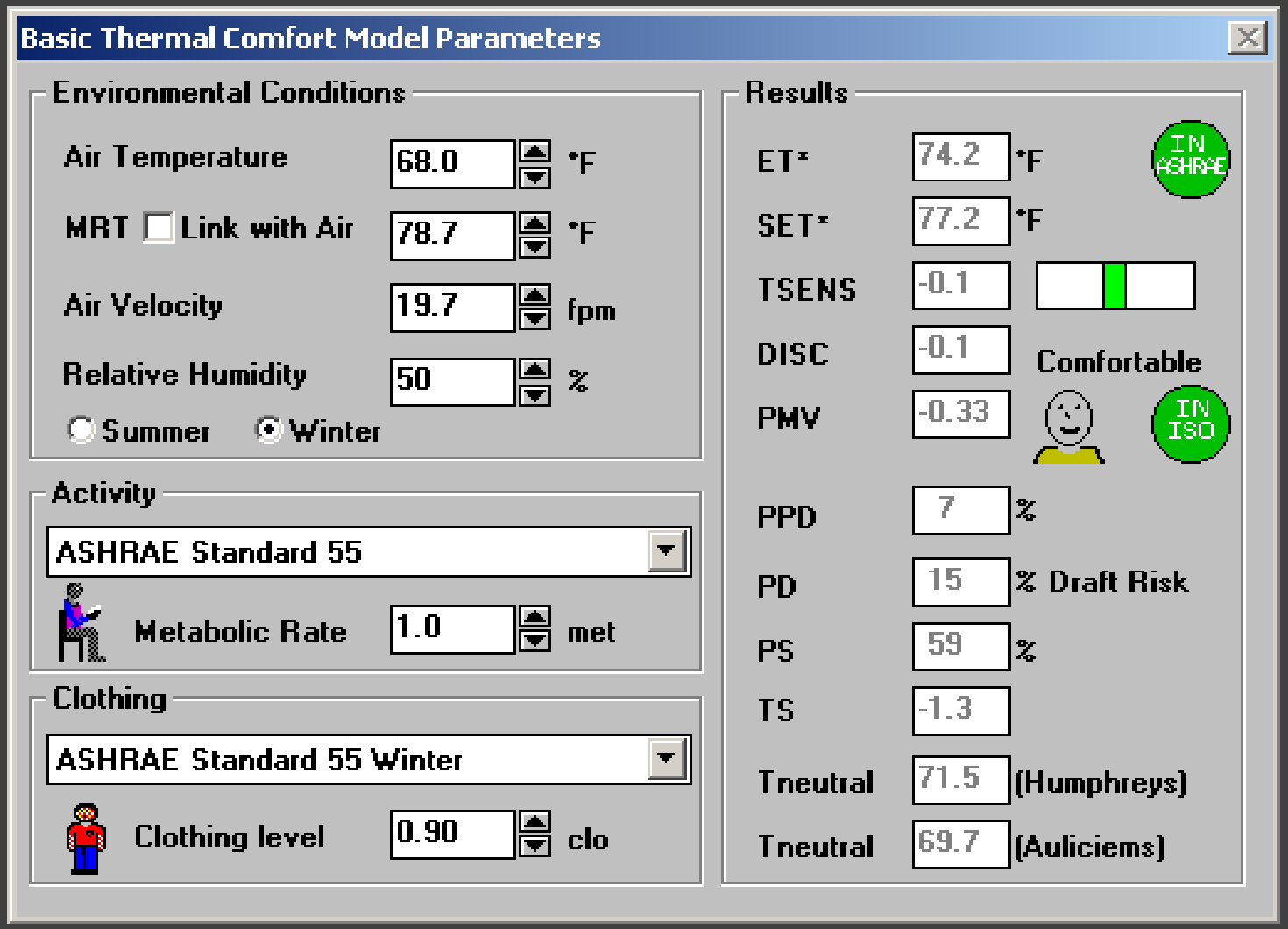
Supplemental Information Energy Model Checked to Reality…



Supplemental Information Comfort of Standard Air Systems



Supplemental Information Comfort of Radiant Systems