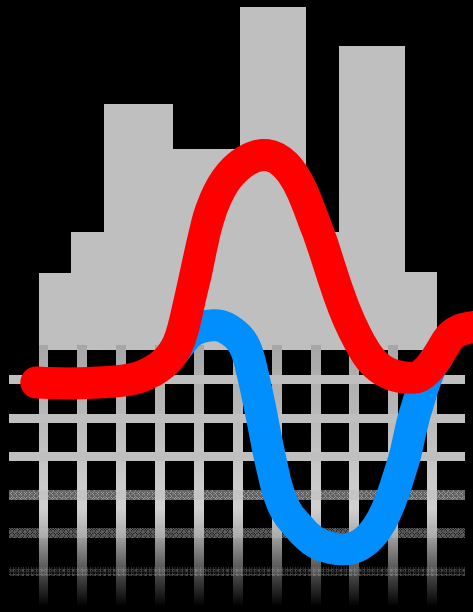


Facility Dynamics
ENGINEERING

Introduction to the Controlled Systems

Load Dynamics

Presented By:

David Sellers; Facility Dynamics Engineering

Senior Engineer

NAVFAC, San Diego

A Bit About Me

1972

- Set out to be an airplane mechanic and aircraft maintenance engineer

A Bit About Me

1976

- Reality intervenes

Image Courtesy www.kpluwonders.org/

A Bit About Me

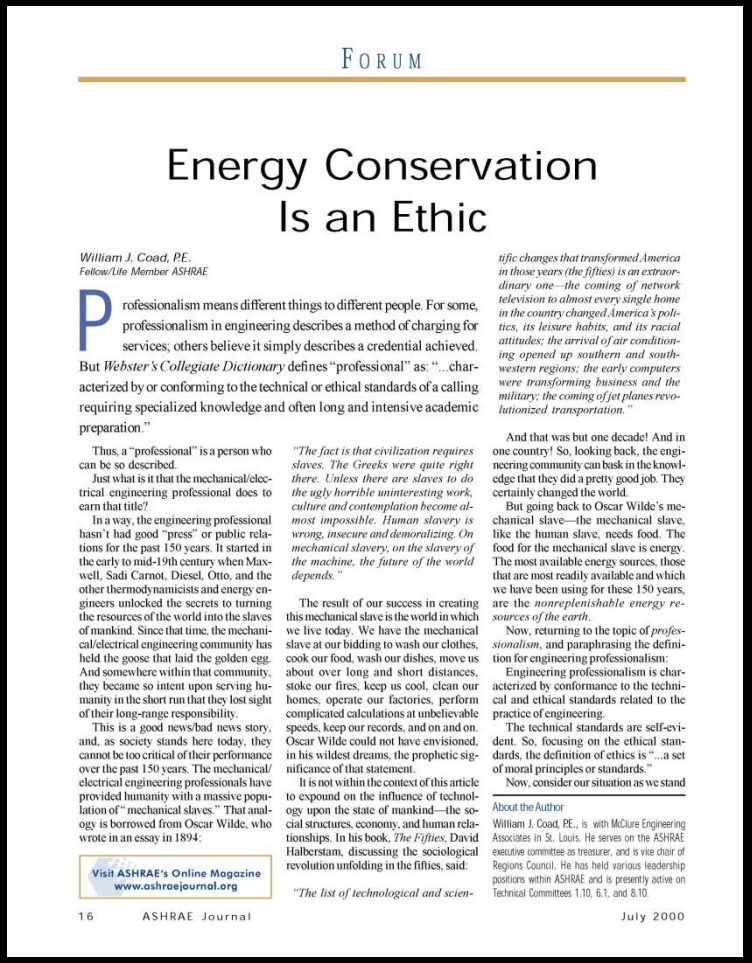
1976

- Bill Coad inspires me to think a different way…

  … that is to practice our profession with an emphasis upon our responsibility to protect the long-range interests of the society we serve and, specifically, to incorporate the ethics of energy conservation and environmental preservation in everything we do.

  ASHRAE Journal, vol. 42, no. 7, p. 16-21

  www.ASHRAE.org



FORUM

Energy Conservation Is an Ethic

William J. Coad, P.E.
Fellow/Life Member ASHRAE

Professionalism means different things to different people. For some, professionalism in engineering describes a method of charging for services; others believe it simply describes a credential achieved. But *Webster's Collegiate Dictionary* defines "professional" as: "…characterized by or conforming to the technical or ethical standards of a calling requiring specialized knowledge and often long and intensive academic preparation."

Thus, a "professional" is a person who can be so described.

Just what is it that the mechanical/electrical engineering professional does to earn that title?

In a way, the engineering professional hasn't had good "press" or public relations for the past 150 years. It started in the early to mid-19th century when Maxwell, Sadi Carnot, Diesel, Otto, and the other thermodynamicists and energy engineers unlocked the secrets to turning the resources of the world into the slaves of mankind. Since that time, the mechanical/electrical engineering community has held the goose that laid the golden egg. And somewhere within that community, they became so intent upon serving humanity in the short run that they lost sight of their long-range responsibility.

This is a good news/bad news story, and, as society stands here today, they cannot be too critical of their performance over the past 150 years. The mechanical/electrical engineering professionals have provided humanity with a massive population of "mechanical slaves." That analogy is borrowed from Oscar Wilde, who wrote in an essay in 1894:

"The fact is that civilization requires slaves. The Greeks were quite right there. Unless there are slaves to do the ugly horrible uninteresting work, culture and contemplation become almost impossible. Human slavery is wrong, insecure and demoralizing. On mechanical slavery, on the slavery of the machine, the future of the world depends."

The result of our success in creating this mechanical slave is the world in which we live today. We have the mechanical slave at our bidding to wash our clothes, cook our food, wash our dishes, move us about over long and short distances, stoke our fires, keep us cool, clean our homes, operate our factories, perform complicated calculations at unbelievable speeds, keep our records, and on and on. Oscar Wilde could not have envisioned, in his wildest dreams, the prophetic significance of that statement.

It is not within the context of this article to expound on the influence of technology upon the state of mankind—the social structures, economy, and human relationships. In his book, *The Fifties*, David Halberstam, discussing the sociological revolution unfolding in the fifties, said:

"The list of technological and scientific changes that transformed America in those years (the fifties) is an extraordinary one—the coming of network television to almost every single home in the country changed America's politics, its leisure habits, and its racial attitudes; the arrival of air conditioning opened up southern and southwestern regions; the early computers were transforming business and the military; the coming of jet planes revolutionized transportation."

And that was but one decade! And in one country! So, looking back, the engineering community can bask in the knowledge that they did a pretty good job. They certainly changed the world.

But going back to Oscar Wilde's mechanical slave—the mechanical slave, like the human slave, needs food. The food for the mechanical slave is energy. The most available energy sources, those that are most readily available and which we have been using for these 150 years, are the *nonreplenishable energy resources of the earth*.

Now, returning to the topic of *professionalism*, and paraphrasing the definition for engineering professionalism:

Engineering professionalism is characterized by conformance to the technical and ethical standards related to the practice of engineering.

The technical standards are self-evident. So, focusing on the ethical standards, the definition of ethics is "…a set of moral principles or standards."

Now, consider our situation as we stand

About the Author

William J. Coad, P.E., is with McClure Engineering Associates in St. Louis. He serves on the ASHRAE executive committee as treasurer, and is vice chair of Regions Council. He has held various leadership positions within ASHRAE and is presently active on Technical Committees 1.10, 6.1, and 8.10.

A Bit About Me

1976 - 1984

- I change career paths and go to work for McClure Engineering in St. Louis, MO
  - Field technician
  - Control system designer
  - Mechanical designer
  - Project engineer
- I am blessed with great mentors (through-out my career)

A Bit About Me

1984 - 1986

- I go on sabbatical to work for MCC Powers
  - Immersed in a specific system
  - Exposed to process control
  - I crash my first control system
  - Begin to realize there is a fundamental lack of understanding of control systems on the part of many designers

A Bit About Me

1984 - 1986

- My sabbatical continues as I work for Murphy Company, Mechanical Contractors
  - Control guy
  - Start-up guy
- I blow up my first duct
- I discover I don't like gambling

A Bit About Me

1986 - 1997

- I return to McClure Engineering as a Project Engineer
  - Migrate their control design standards and specs from pneumatics to DDC
  - Do a lot of Health Care work

A Bit About Me

1997

- Move to Oregon to become a facilities engineer at Komatsu Silicon's Hillsboro facility
  - HVAC system owner
  - Process exhaust system owner
  - Central chilled water plant system co-owner
  - DDC system co-owner
  - Fire protection system owner

A Bit About Me

1999 - 2005

- Semiconductor industry downturn continues
  - Plant idled
  - I move to PECI
    - Not-for-profit focused in energy efficiency and sustainability
    - Develop infrastructure for the commissioning industry
    - Discover I can teach if its hands on and technical

A Bit About Me

2005 - Present

- I move to FDE
  - Some new construction Cx
  - Mostly EBCx
  - Third party control system design work
  - A lot of hands-on training
    - Pacific Energy Center
    - Marriott
  - Leadership role for FDE's Not-For-Profit division

What We Will Cover in This Module

Part 1

- The dynamic, interactive, nature of the loads served by HVAC systems and the challenges we face when we try to integrate them with a control system
- This is important enough that I will probably bring this up at least once ~~each day~~

Part 2

- An overview of common components in HVAC systems and a bit about their physics and performance dynamics and how those factors might relate to the design of the control system

Some Resources

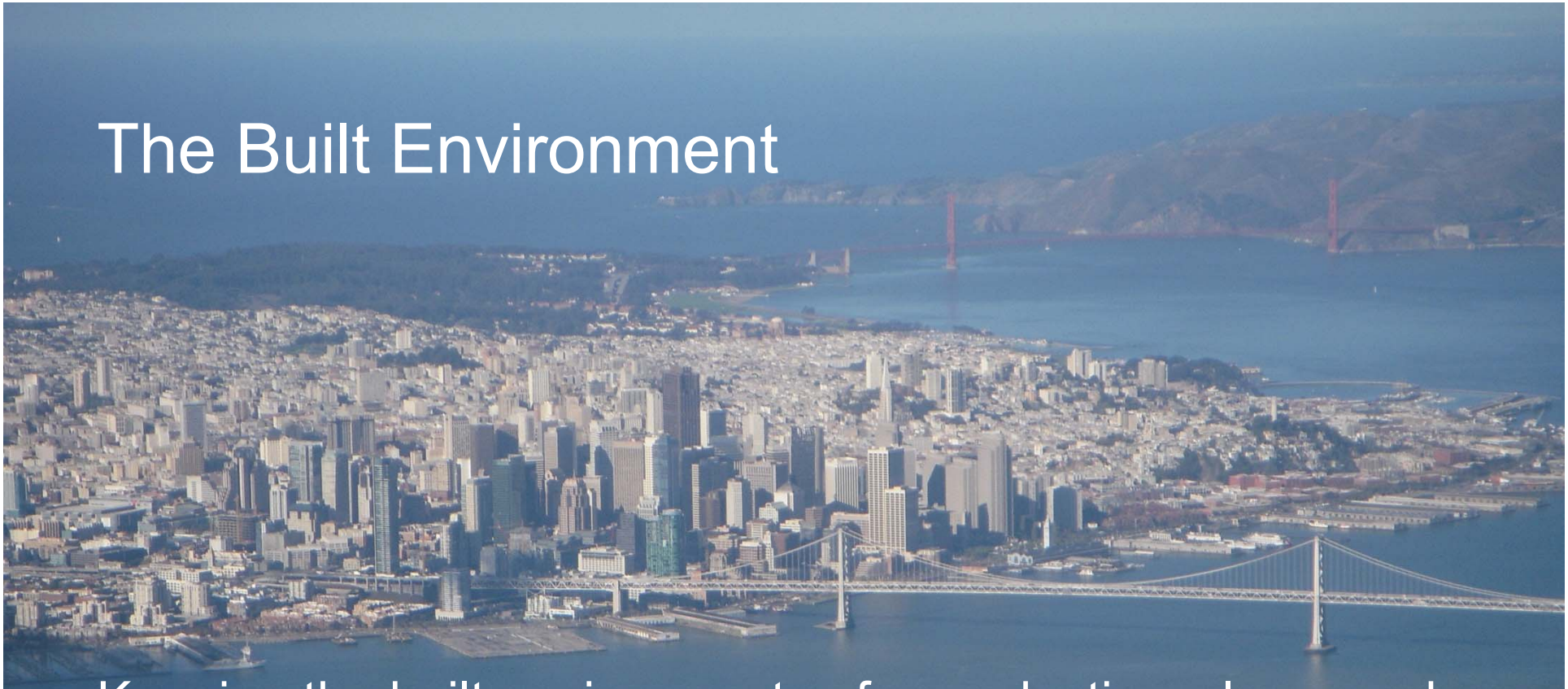
The location for things I hand out or use in class

http://tinyurl.com/CurrentUofWClass

The location of my blog

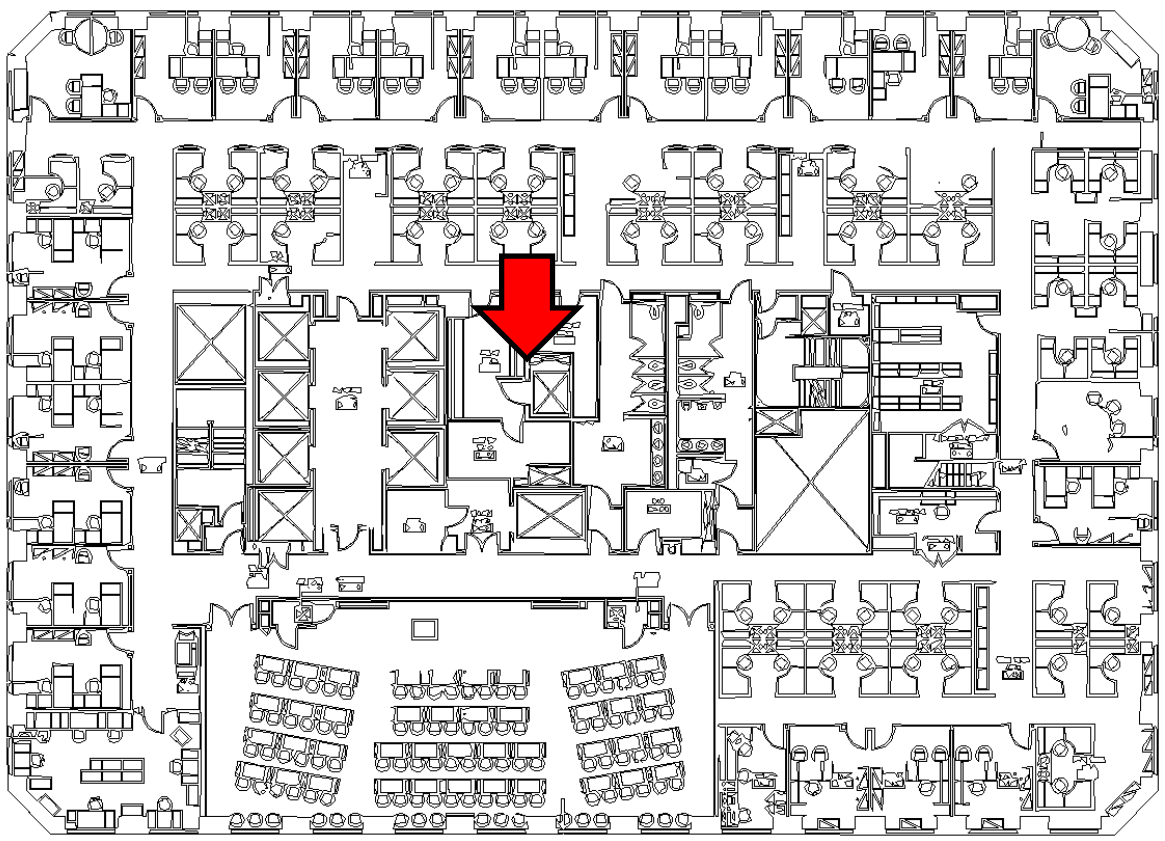
www.Av8rDAS.Wordpress.com

The Built Environment



Keeping the built environment safe, productive, clean, and comfortable is a fundamental goal of HVAC systems and their controls

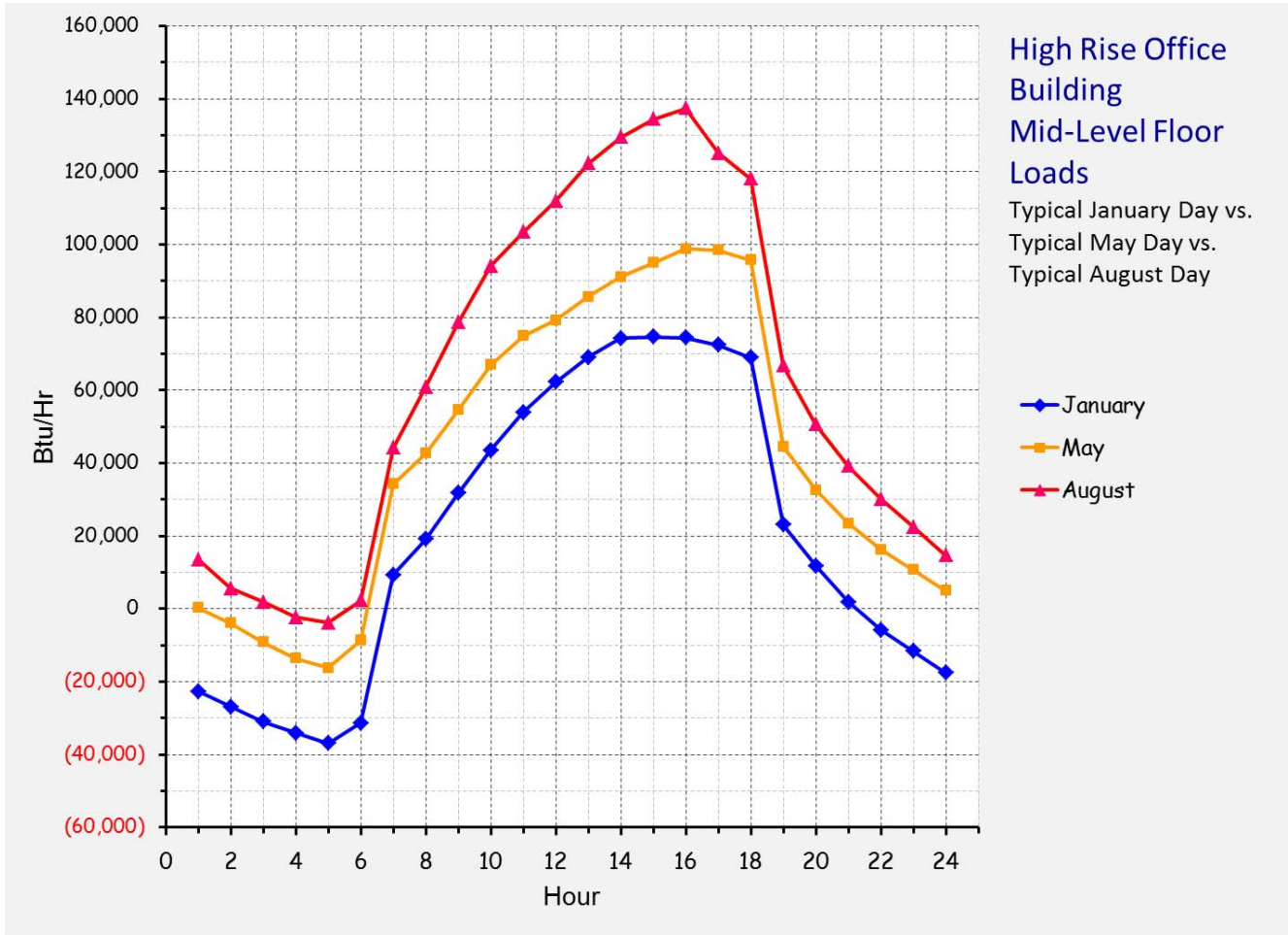
- Ventilation systems control contaminants by introducing filtered, conditioned outdoor air
- Heating and cooling systems track the loads to control comfort



uctive, clean, and
AC systems and

- Ventilation systems control contaminants by introducing filtered, conditioned outdoor air
- Heating and cooling systems track the loads to control comfort

The Loads can be Very Dynamic



The Cooling Requirements Vary with Time of Day and Time of Year

Load Dynamics

A Research Experiment by the FDE NW Research Lab

Dr. Riley Sellers; PhD CTK *LBNL CTPSC **

Hobbes Sellers; Post Doc *Applied Chaos Theory*

* Doctorate of Philosophy - Canine Treat Kinetics - Lower Buchanan National Labs, Canine Treat Preservation Systems Center

Outside = Inside

A Research Experiment by the FDE NW Research Lab

The Experiment

- Use an environmental test chamber to assess the thermal response characteristics of different envelope configurations

Environmental Test Chamber

Outside = Inside

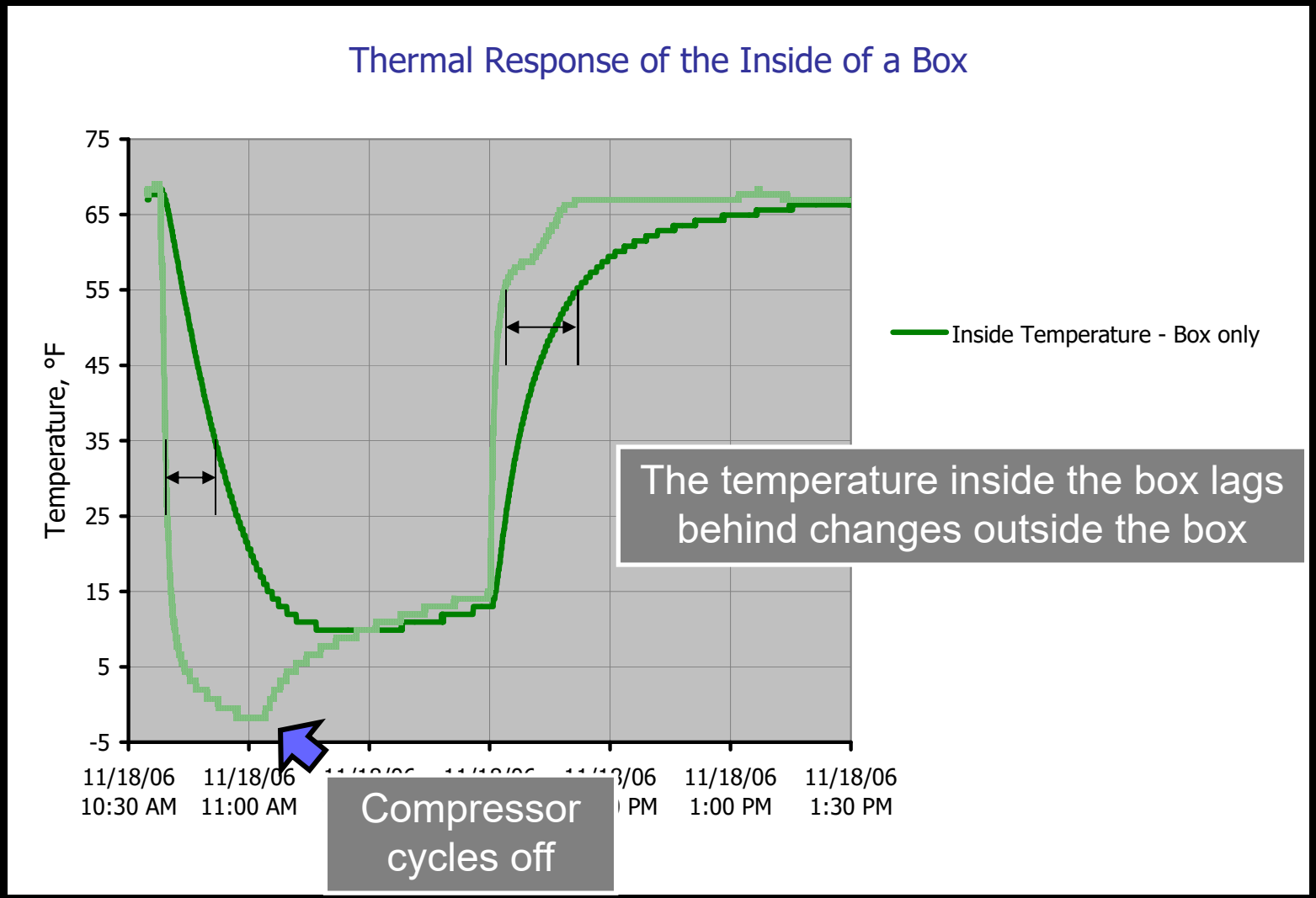
A Research Experiment by the FDE NW Research Lab

Envelope Configuration 1

- Cardboard box, no insulation

Envelope Configuration 1

Test Results – Envelope Configuration 1



Outside = Inside

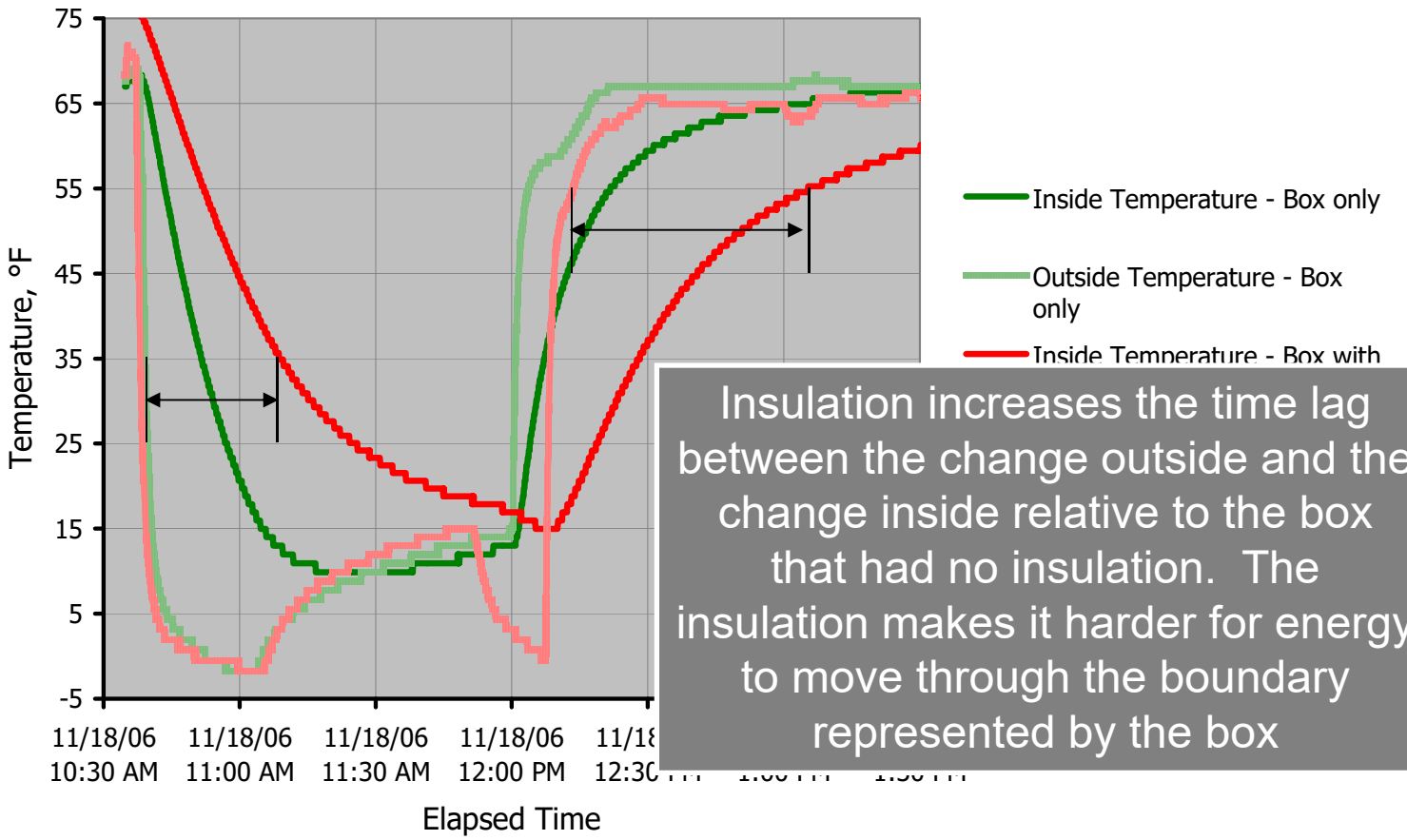
A Research Experiment by the FDE NW Research Lab

Envelope Configuration 2

- Cardboard box, insulated

Envelope Configuration 2

Test Results – Envelope Configuration 2



Outside = Inside

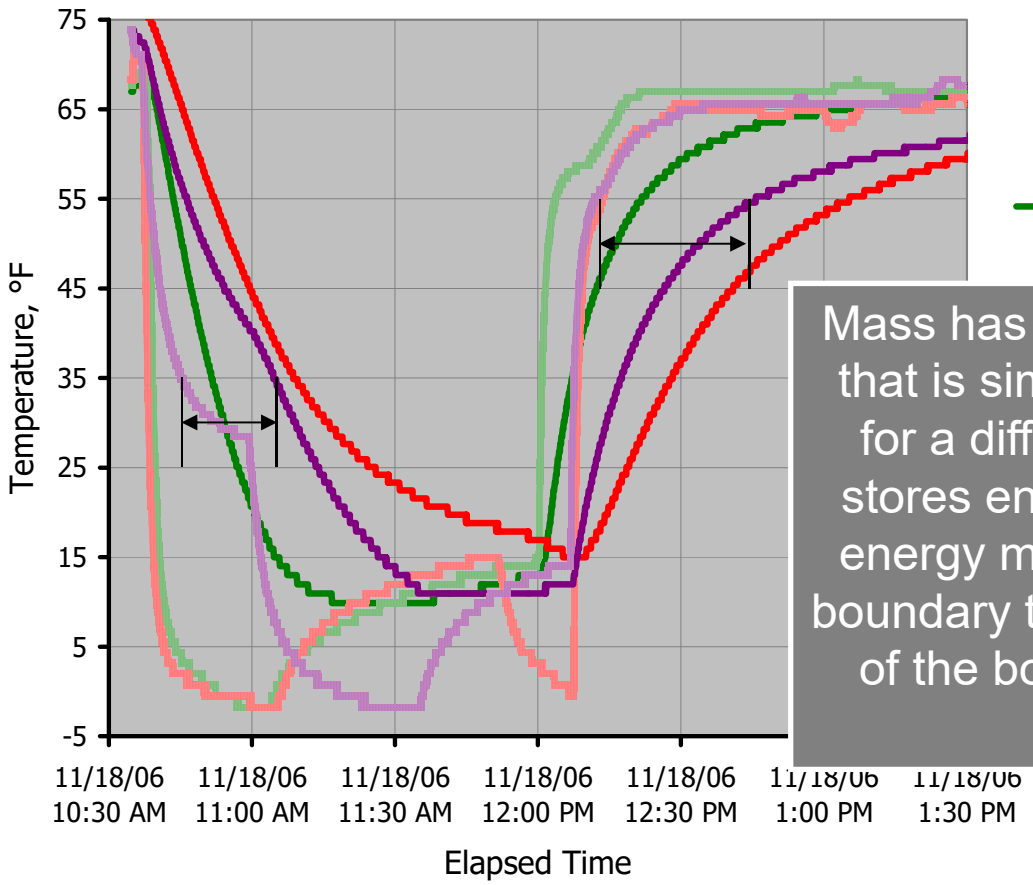
A Research Experiment by the FDE NW Research Lab

Envelope Configuration 3

- Cardboard box with rocks, no insulation

Envelope Configuration 3

Test Results – Envelope Configuration 3



Mass has an impact on the time lag that is similar to the insulation, but for a different reason. The mass stores energy, which means more energy must move across the box boundary to change the temperature of the box, all other things being equal

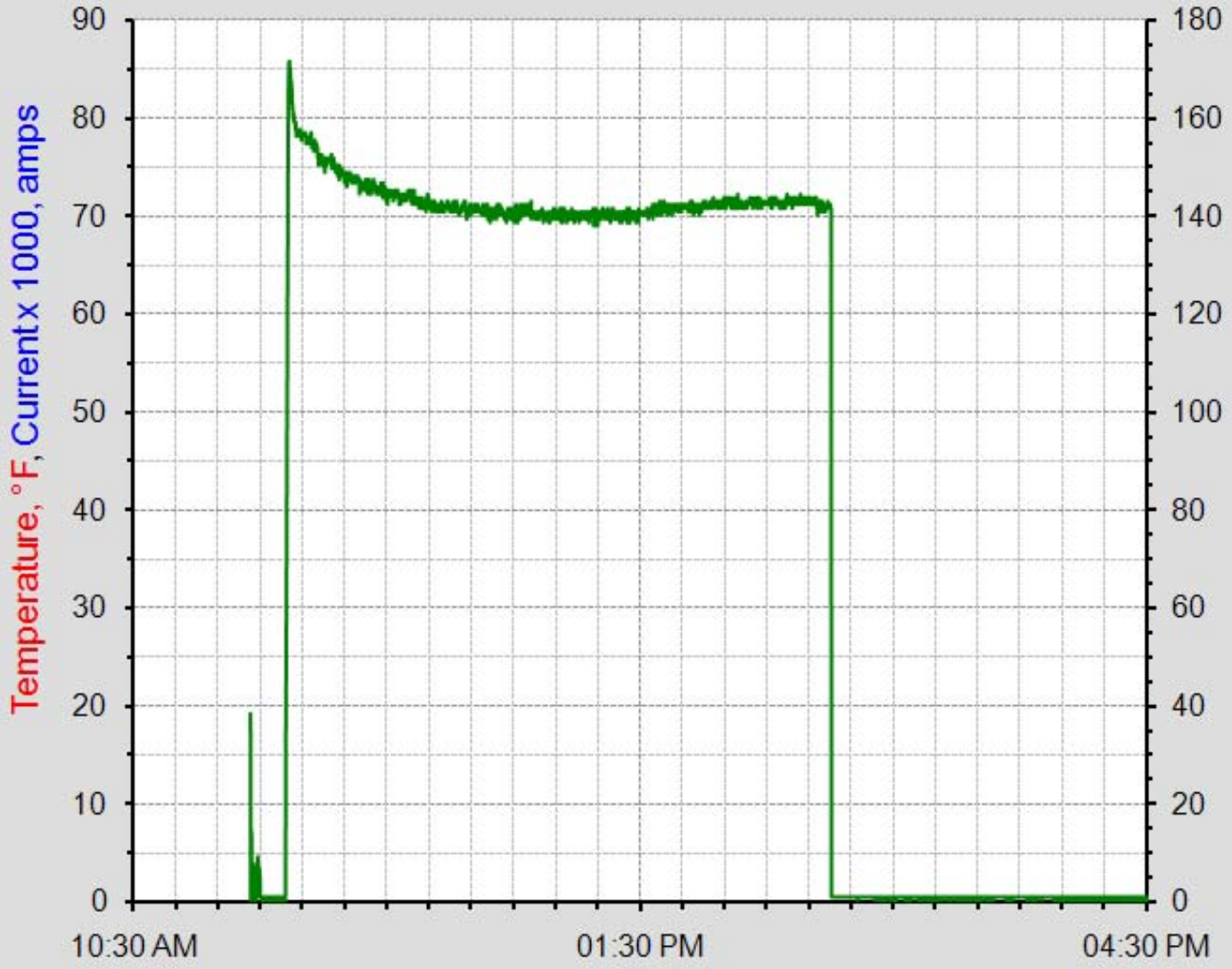
Internal Gains Have Lags Too


onset
HOBO


GEORGIA O'KEE
MORNING GLORY WITH
THE CLEVELAND MUSEUM
Cuisinart

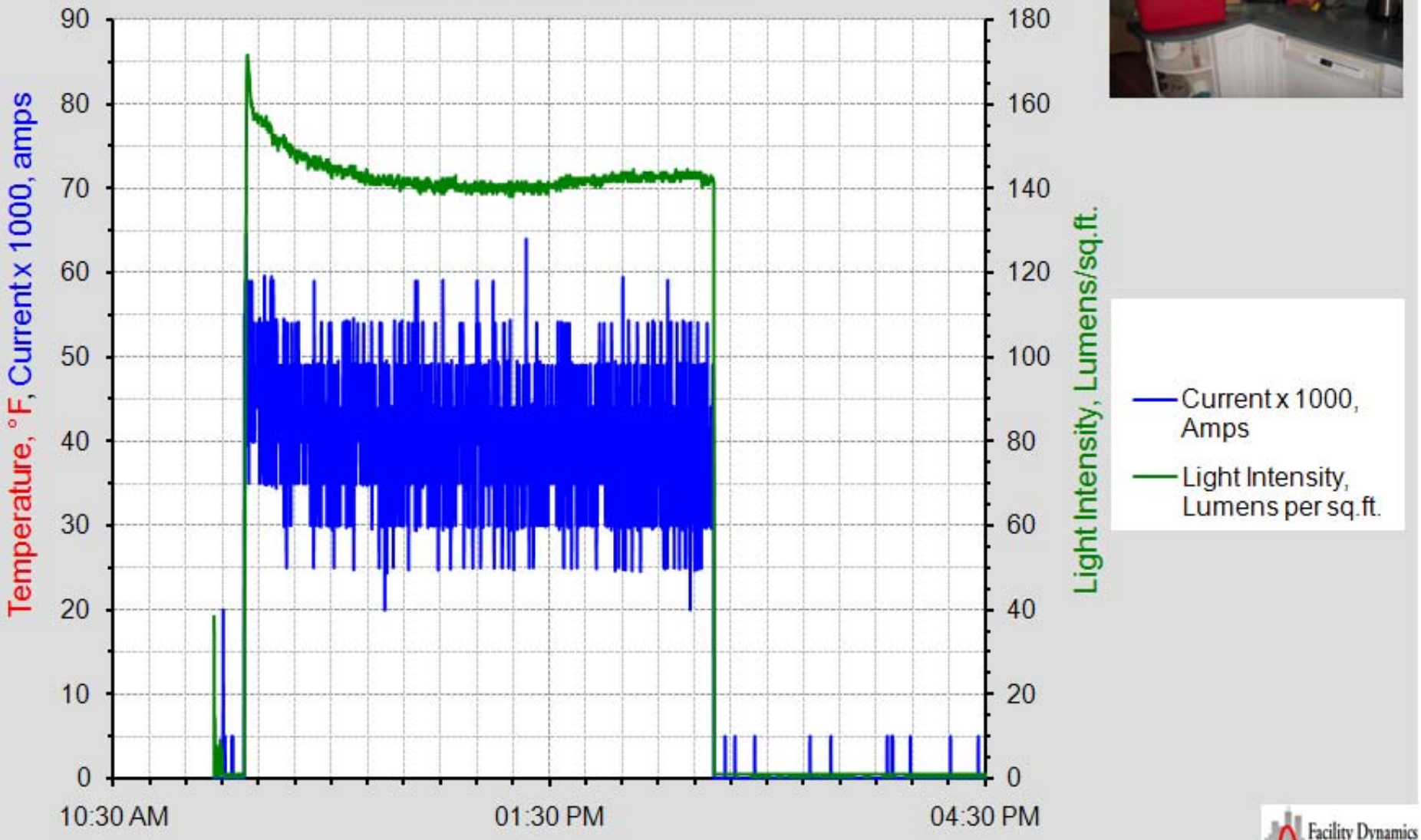
Temperature Inside an Insulated Enclosure

With and Without a Light On



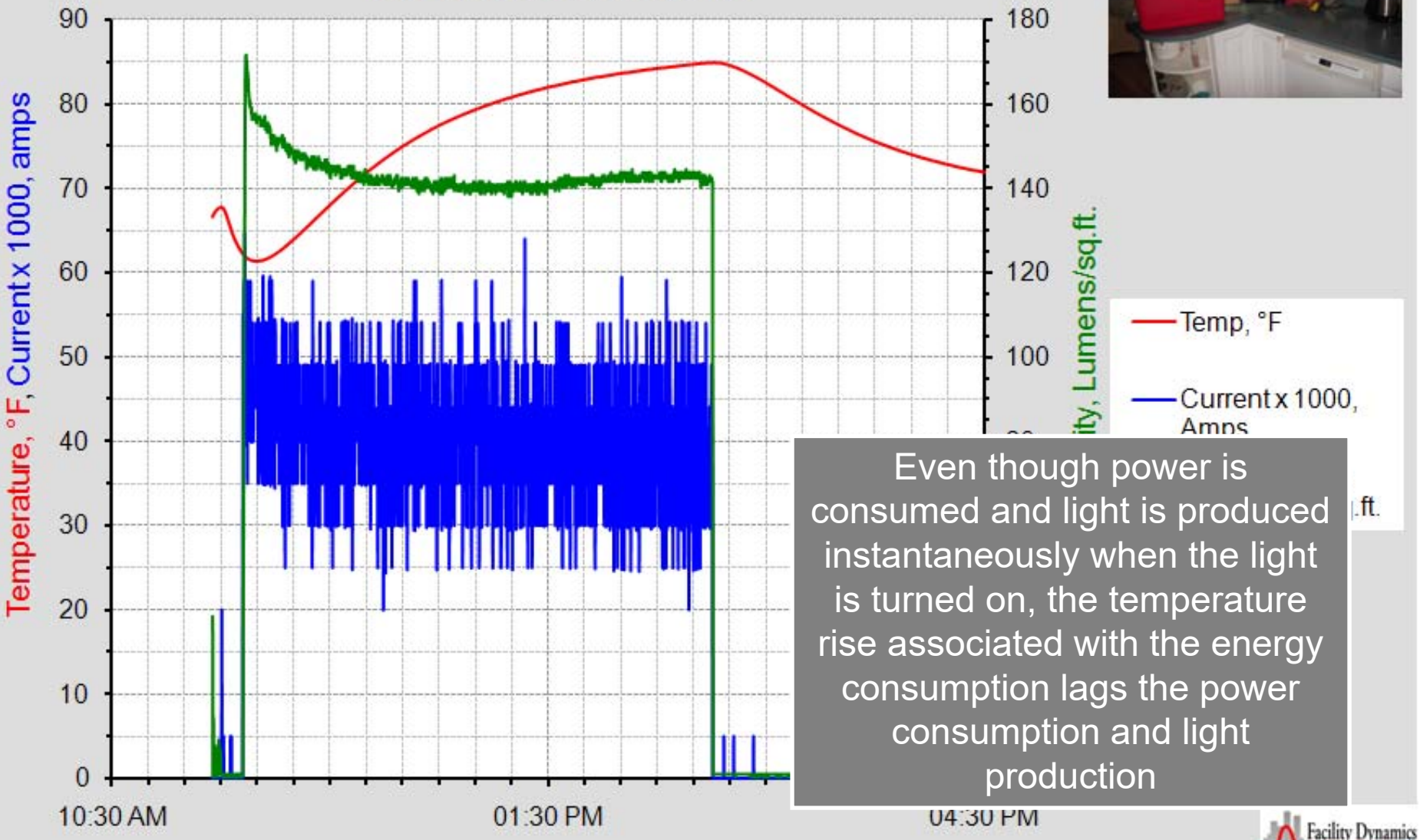
Temperature Inside an Insulated Enclosure

With and Without a Light On



Facility Dynamics Engineering

Temperature Inside an Insulated Enclosure
With and Without a Light On

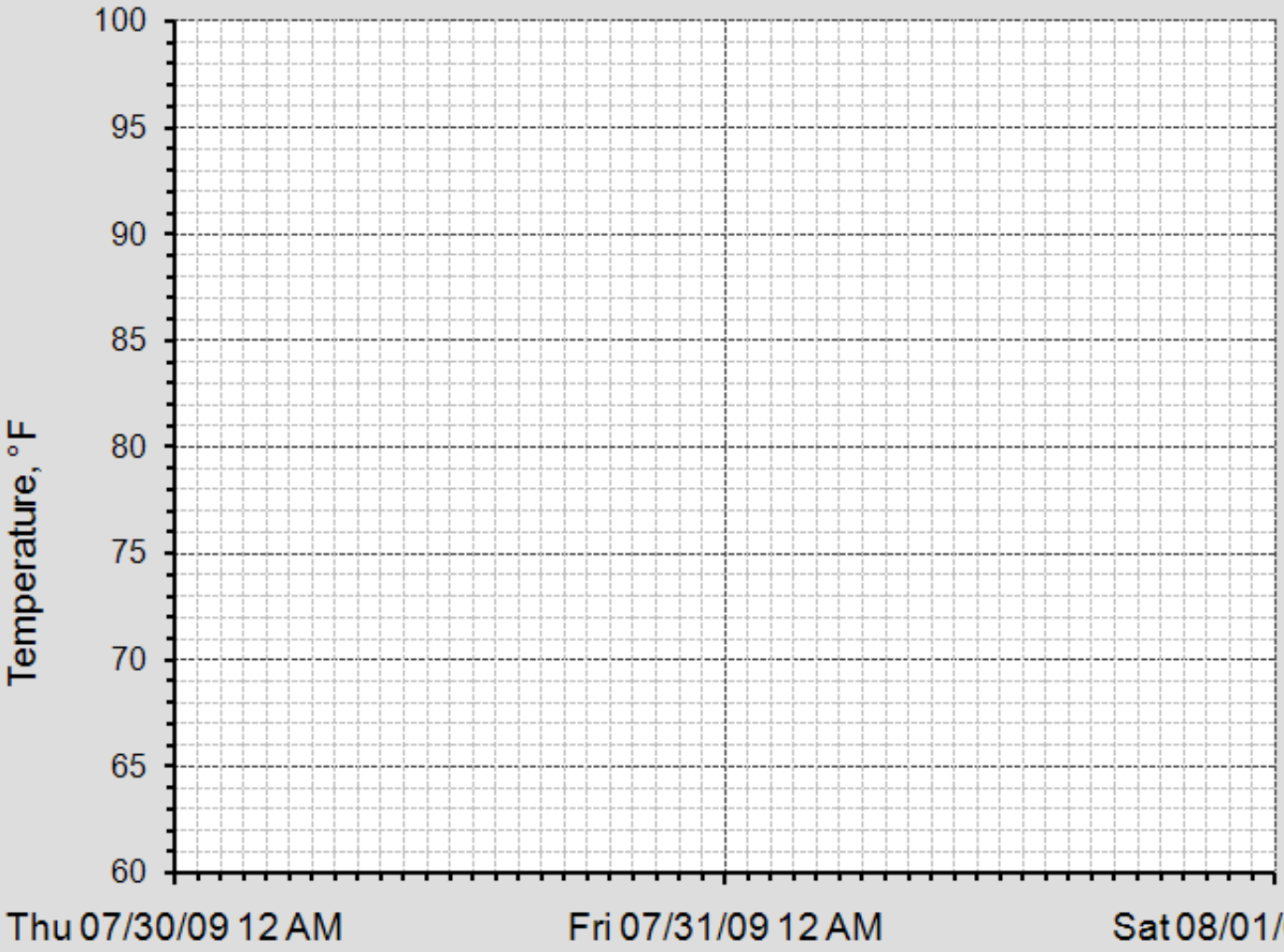


Even though power is consumed and light is produced instantaneously when the light is turned on, the temperature rise associated with the energy consumption lags the power consumption and light production

Everything Interacts with Everything, Even in a Simple Building

8560 North Buchanan, Portland, OR Summer Thermal Response

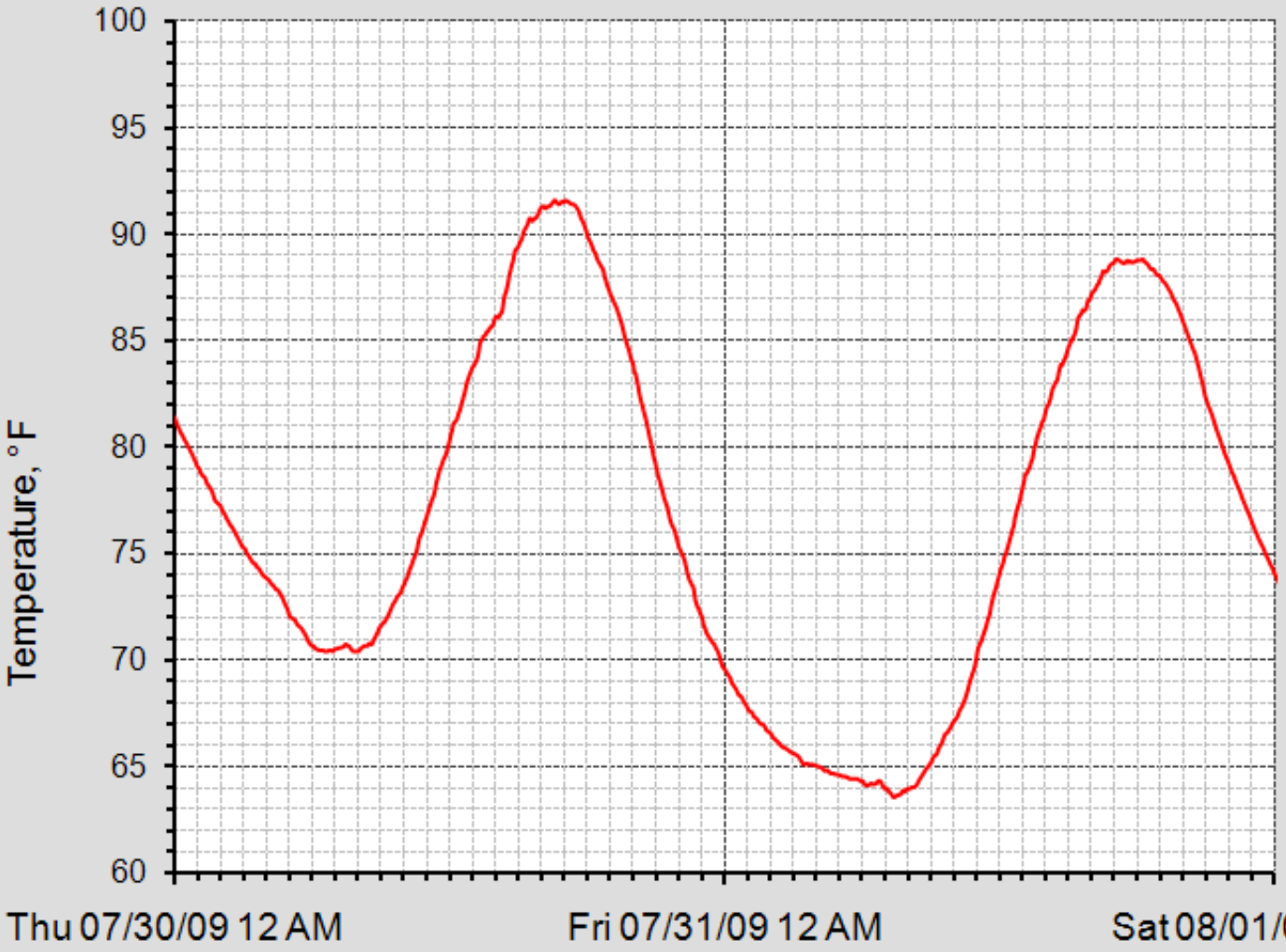
Portand 0.4% Cooling Design Condition - 90/67 °Ft_{db}/t_{wb}, 22°F Daily Range



Single story, light frame construction
Poured concrete basement
No air conditioning
Doors and windows open
Ceiling fans operating

8560 North Buchanan, Portland, OR Summer Thermal Response

Portand 0.4% Cooling Design Condition - 90/67 °Ft_{db}/t_{wb}, 22°F Daily Range



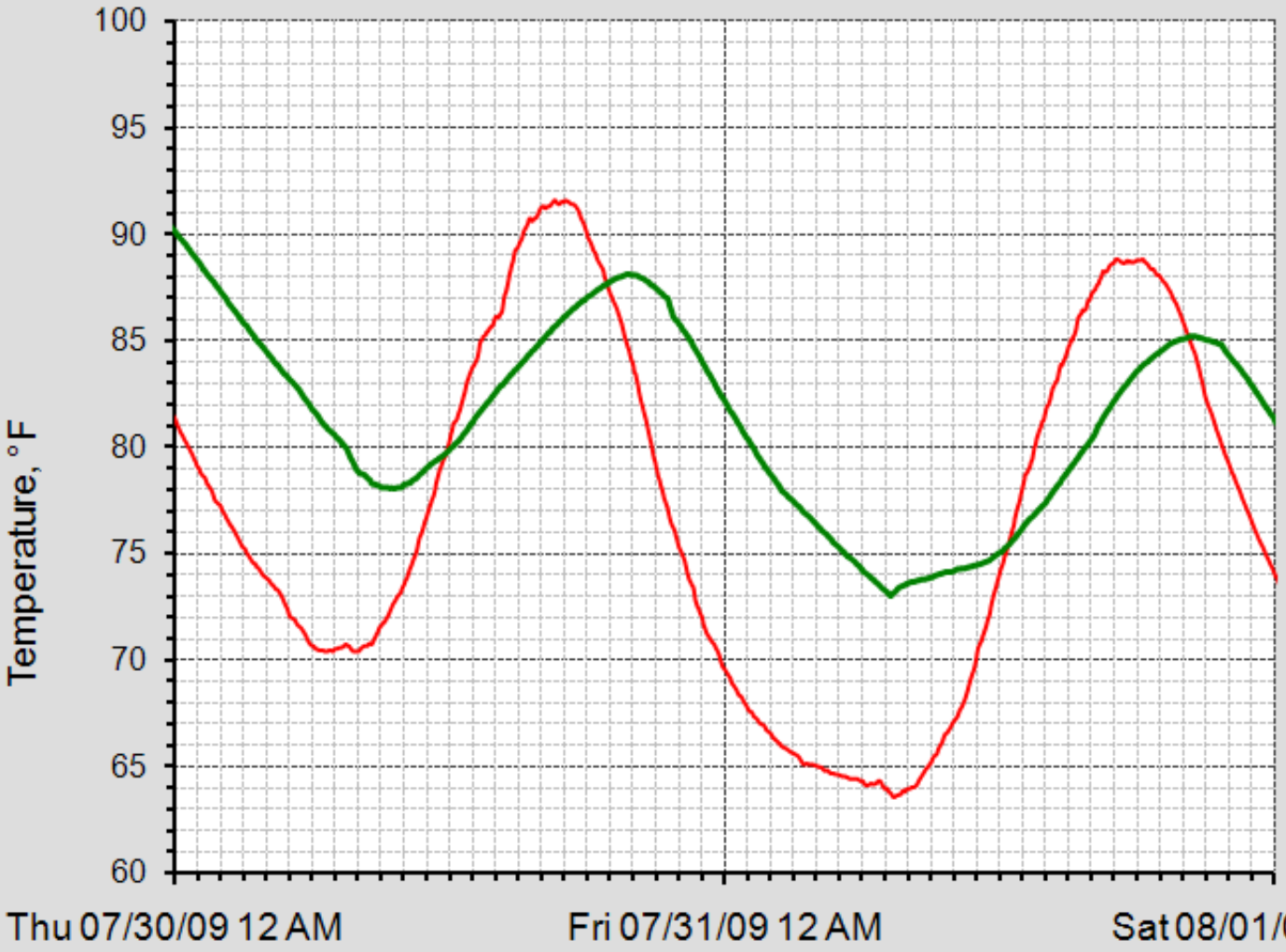
Single story, light frame construction
Poured concrete basement
No air conditioning
Doors and windows open
Ceiling fans operating

Outdoor Temp.; North Side

Facility Dynamics Engineering

8560 North Buchanan, Portland, OR Summer Thermal Response

Portand 0.4% Cooling Design Condition - 90/67 °Ft_{db}/t_{wb}, 22°F Daily Range



Single story, light frame construction
Poured concrete basement
No air conditioning
Doors and windows open
Ceiling fans operating

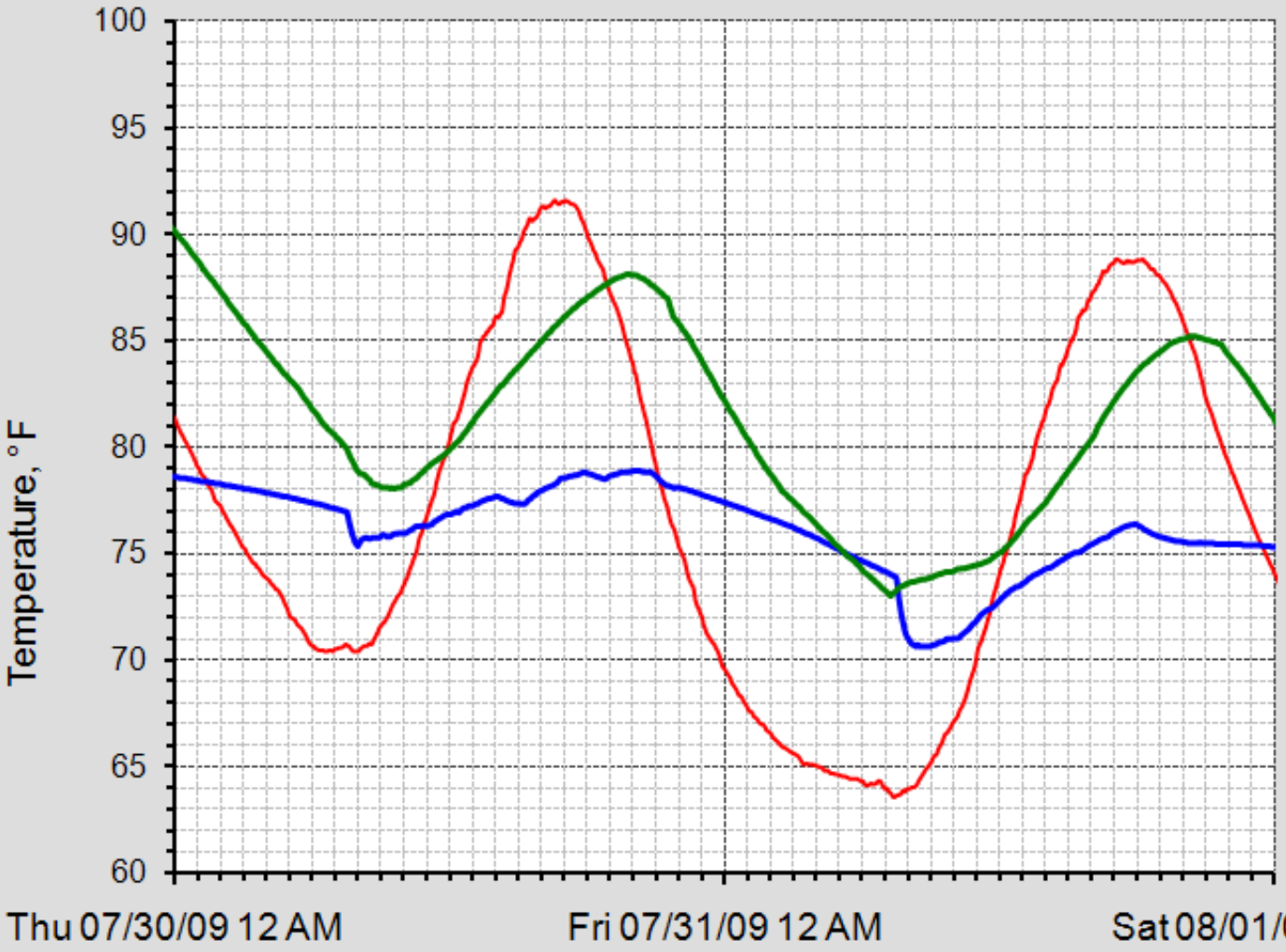
Outdoor Temp.; North Side

Upstairs Living Room Temp.

Facility Dynamics Engineering

8560 North Buchanan, Portland, OR Summer Thermal Response

Portand 0.4% Cooling Design Condition - 90/67 °Ft_{db}/t_{wb}, 22°F Daily Range

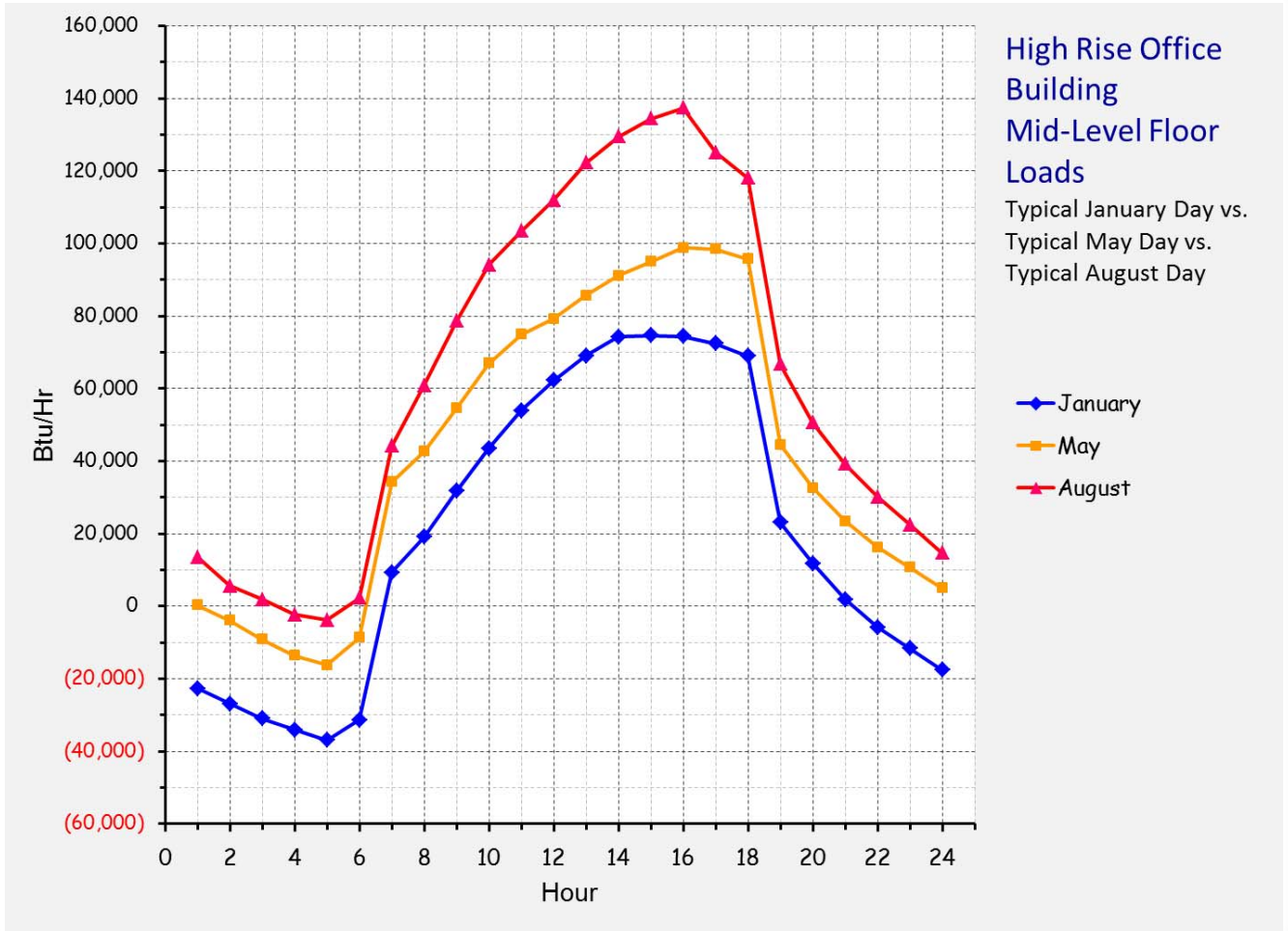


Single story, light frame construction
Poured concrete basement
No air conditioning
Doors and windows open
Ceiling fans operating

- Outdoor Temp.; North Side
- Basement Office Temp.
- Upstairs Living Room Temp.

Cool the Building with Cool Outdoor Air

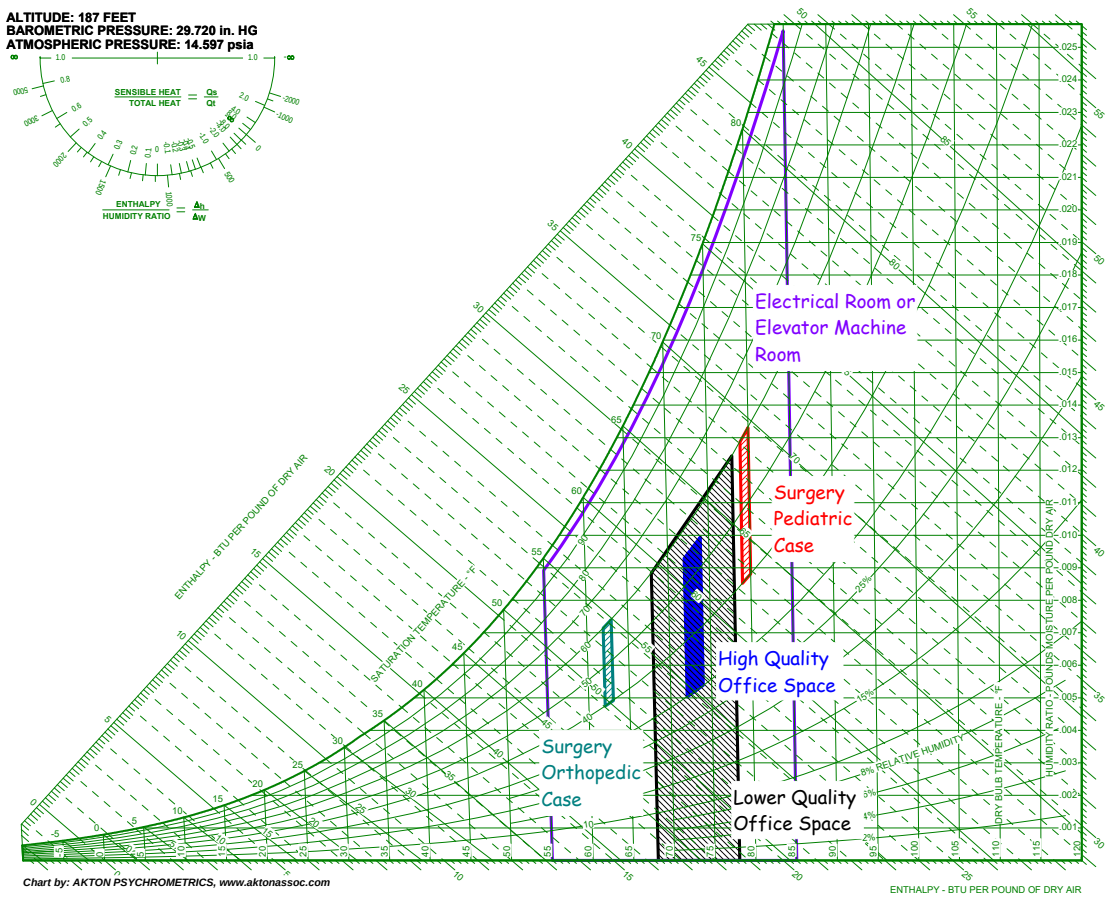
Simple in Concept; Challenging in Reality



The Cooling Requirements Vary with Time of Day and Time of Year

Cool the Building with Cool Outdoor Air

Simple in Concept; Challenging in Reality

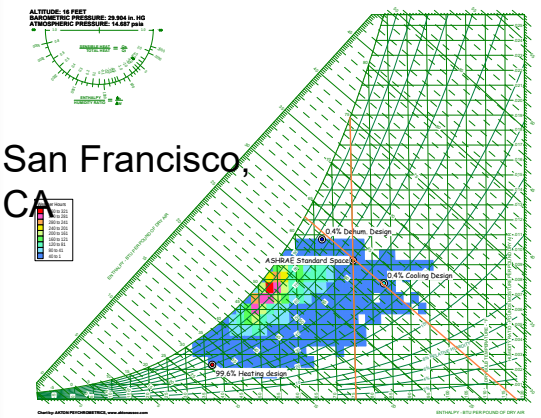


The Suitability of Outdoor Air for Cooling Varies with the Application

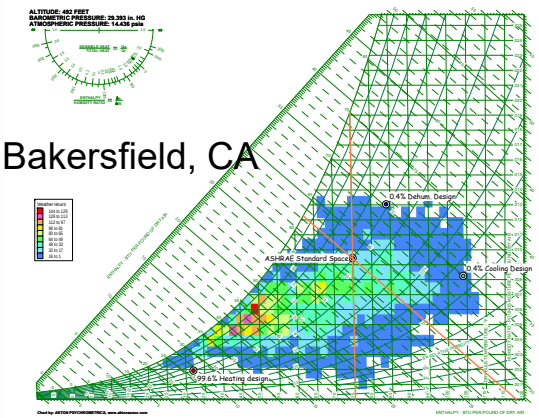
Cool the Building with Cool Outdoor Air

Simple in Concept; Challenging in Reality

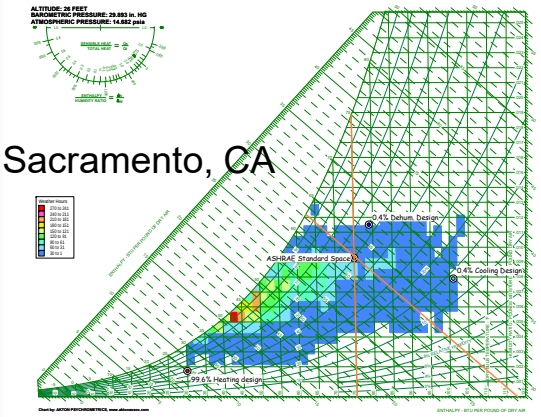
San Francisco, CA



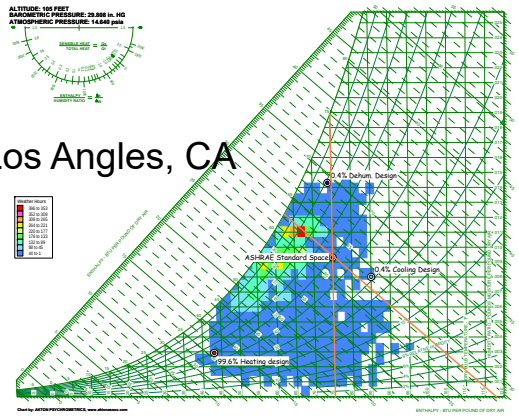
Bakersfield, CA



Sacramento, CA



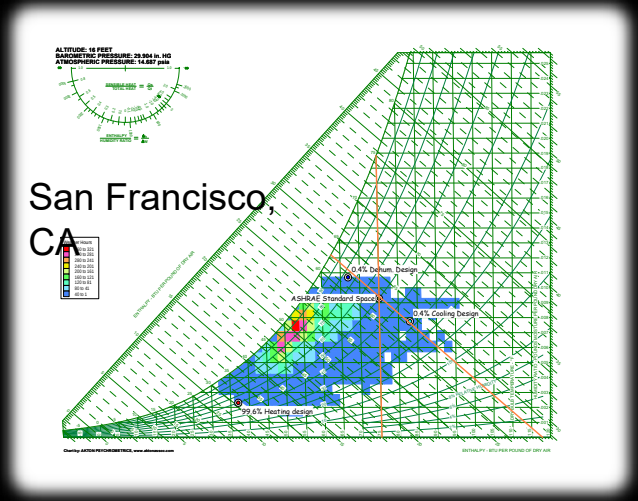
Los Angles, CA

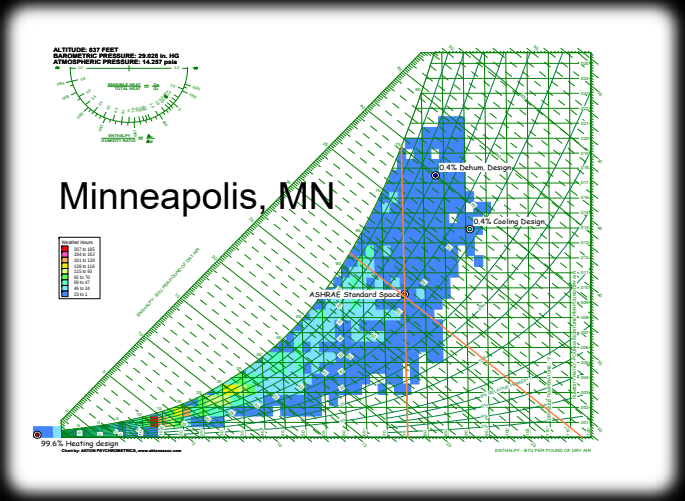


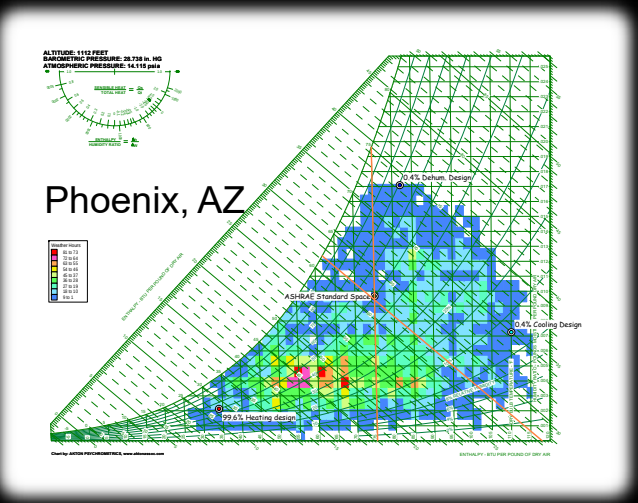
The Cooling Requirements Vary with Location as Does the Suitability of Outdoor Air for Cooling

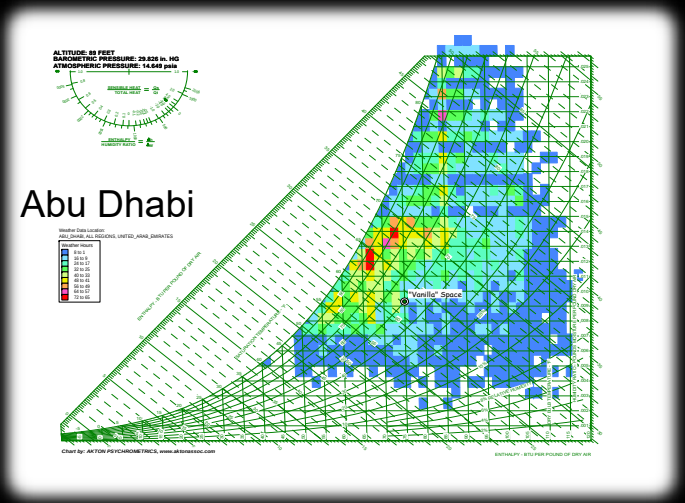
Cool the Building with Cool Outdoor Air

Simple in Concept; Challenging in Reality





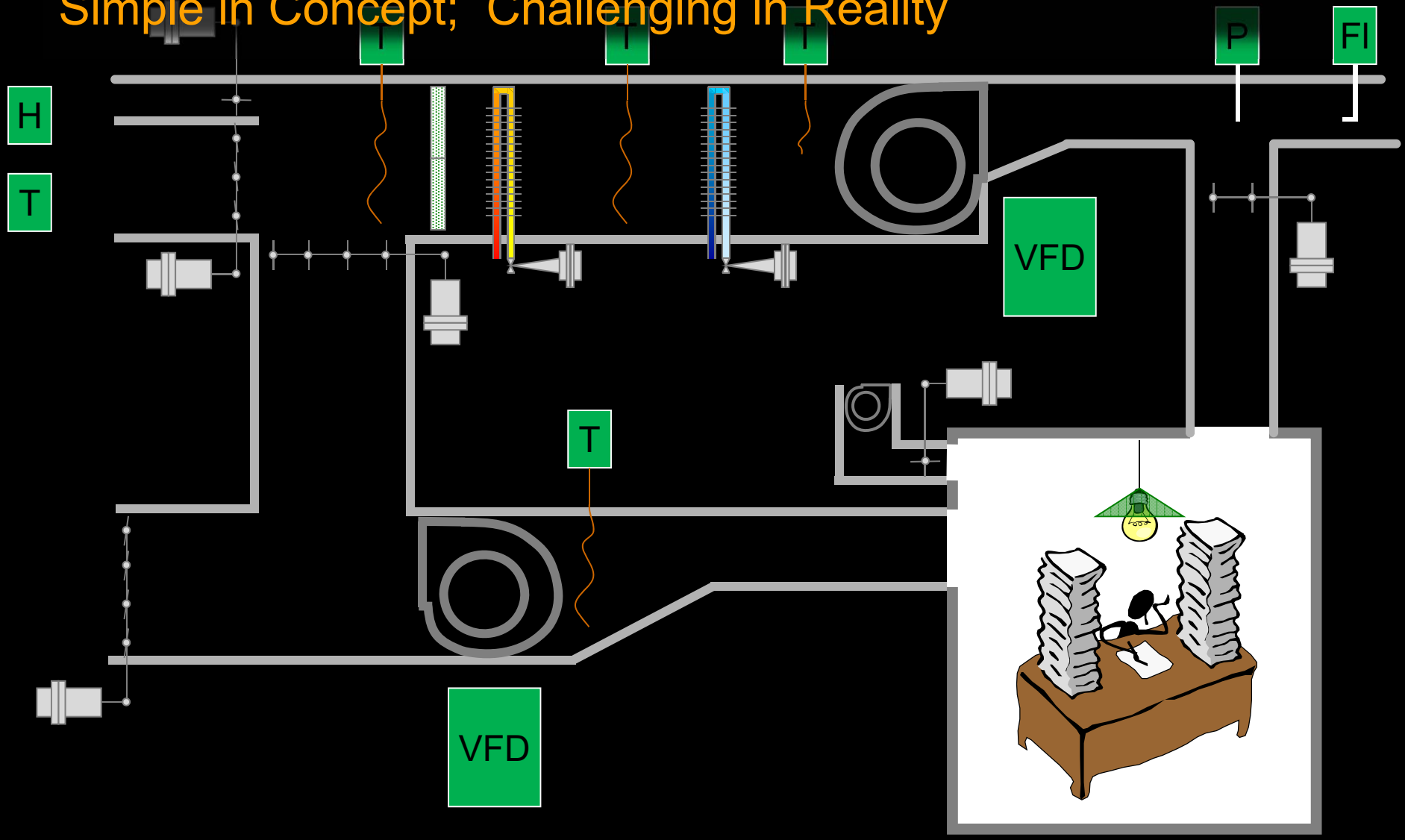


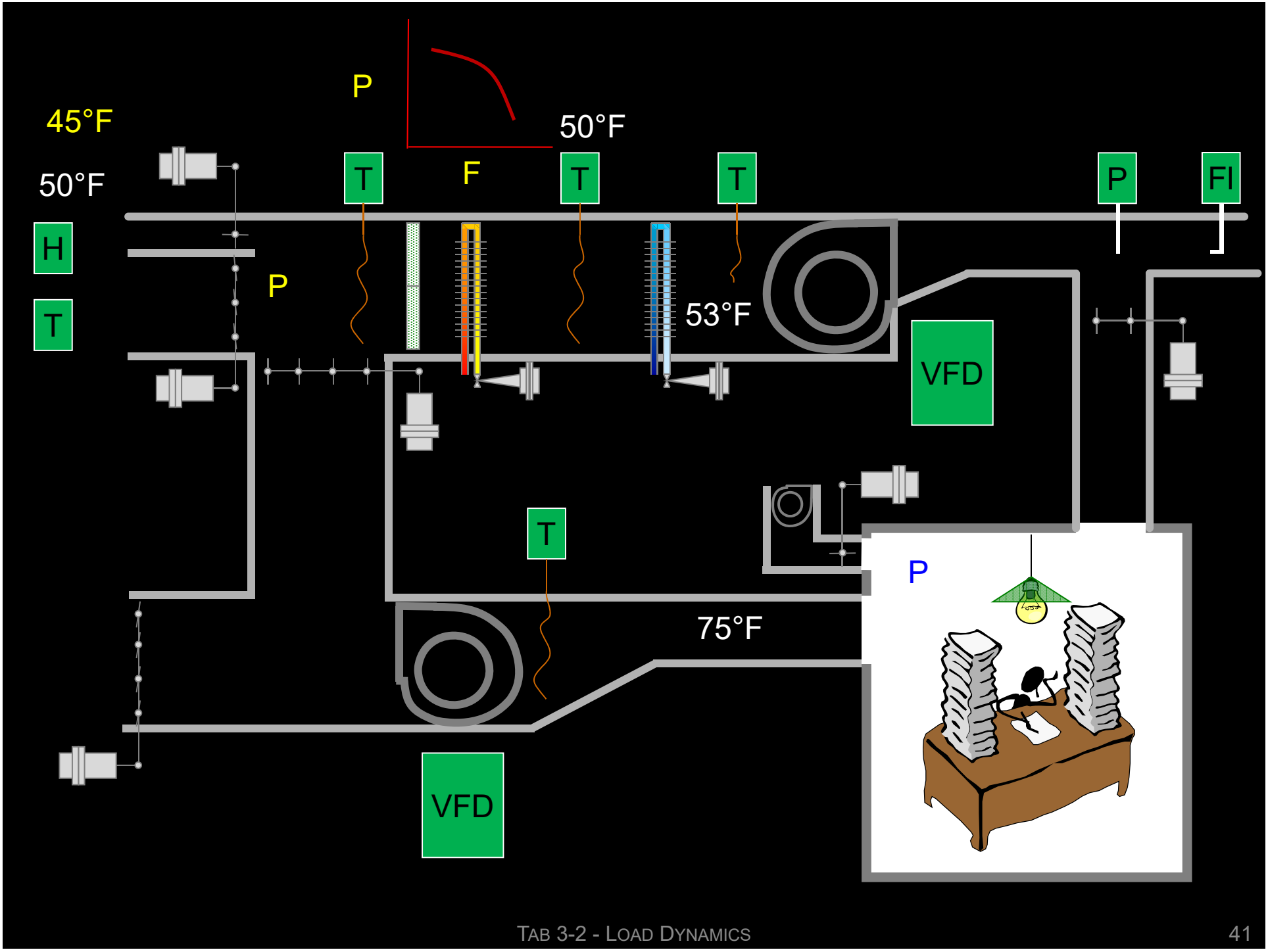


The Cooling Requirements Vary with Location as Does the Suitability of Outdoor Air for Cooling

Cool the Building with Cool Outdoor Air

Simple in Concept; Challenging in Reality




P
45°F
50°F
50°F
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53°F
VFD
T
P
75°F
VFD

Aside from those things, it should not be too hard to get a control system to work

Bottom Lines

1. The loads our HVAC systems deal with are very dynamic
   a. System dependent
   b. Process dependent
   c. Climate dependent
   d. Envelope dependent
2. The components in our systems are highly interactive
   a. Process 1 output = Process 2 input; Process 2 output = Process 3 input; Process “n” output – Process “n+1” input; Process “n+1” output = Process 1 input
   b. The control system can mitigate this potential problem or propagate the problem
3. I like puppies and kittens