

# DEFERRED MAINTENANCE

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**“The Cost Of Doing Nothing”**

## PRESENTERS:

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# INTRODUCTION

## OVERVIEW

- Base Case Energy Model
- Factors Affecting Energy Performance: **“13 Point Checklist”**
- Worse Case Scenarios
- What Have We Learned?



# INTRODUCTION

## BACKGROUND

- Energy Model: Carrier Hourly Analysis Program (HAP) v.4.4
- ASHRAE 90.1 2004: Used as standard reference point
- Energy comparisons are based on cost
- Unless noted otherwise, energy differences are based on effect to energy consumption for entire building.



**BASE CASE**

## BASE CASE

### BUILDING DESCRIPTION

#### **SAS Hall**

N.C. State University

New building

Constructed 2009

5-story

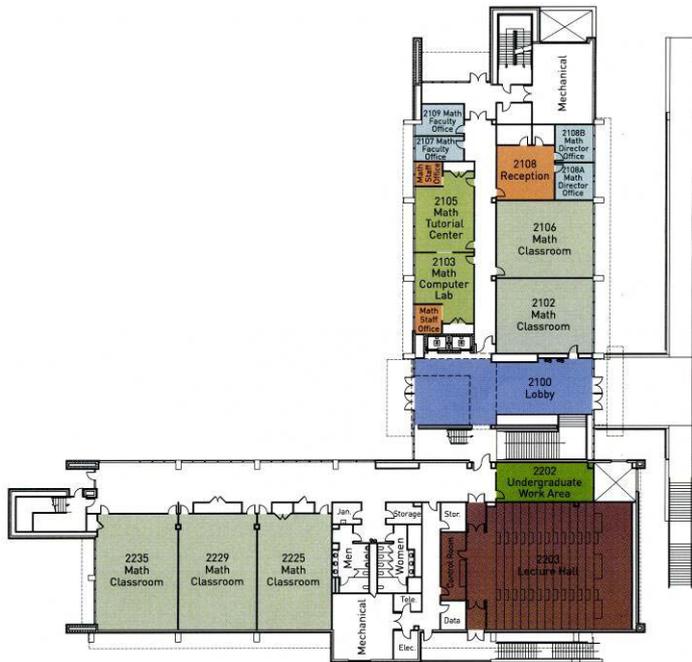
115,000 SF

Atrium



# BASE CASE

## BUILDING DESCRIPTION



General Classrooms  
Faculty Offices



Lecture Halls  
Facilities Operations Hub

## BASE CASE

### BUILDING DESCRIPTION

#### HVAC

- Two air handling units per floor
- VAV terminals with hot water reheat
- Campus chilled water & steam

(however, for comparison purposes, the energy model has been adjusted for this presentation to be based on a building boiler and chiller system)

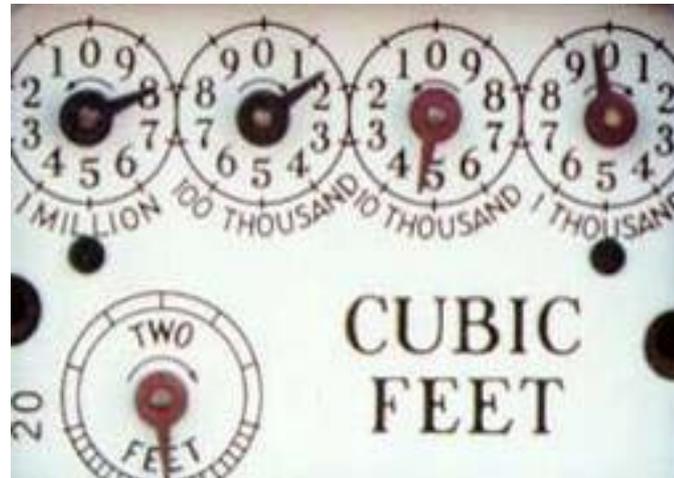


## BASE CASE

### BUILDING PERFORMANCE

#### Total Energy

Annual Cost = \$ 164,200



## BASE CASE

### BUILDING PERFORMANCE

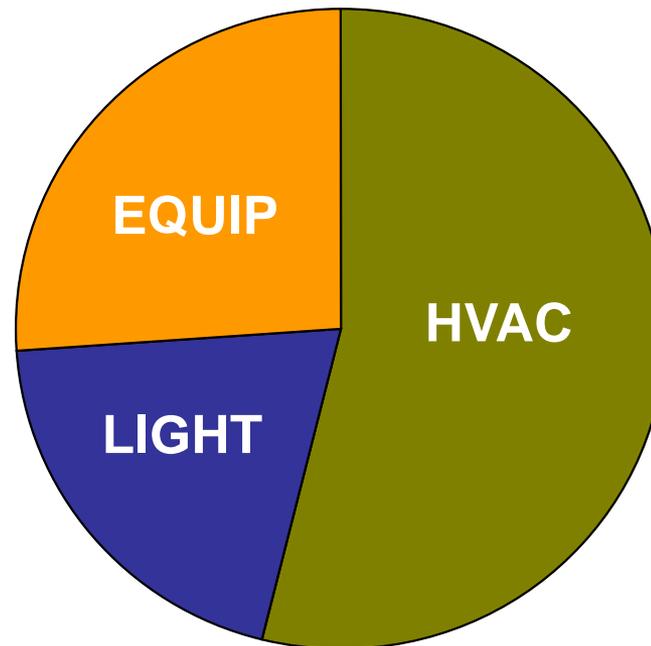
#### Total Energy

Breakdown:

HVAC 54%

Lighting 20%

Equipment 26%



## BASE CASE

### **BUILDING PERFORMANCE**

#### HVAC Energy

Annual Cost = \$88,467



## BASE CASE

### BUILDING PERFORMANCE

#### HVAC Energy

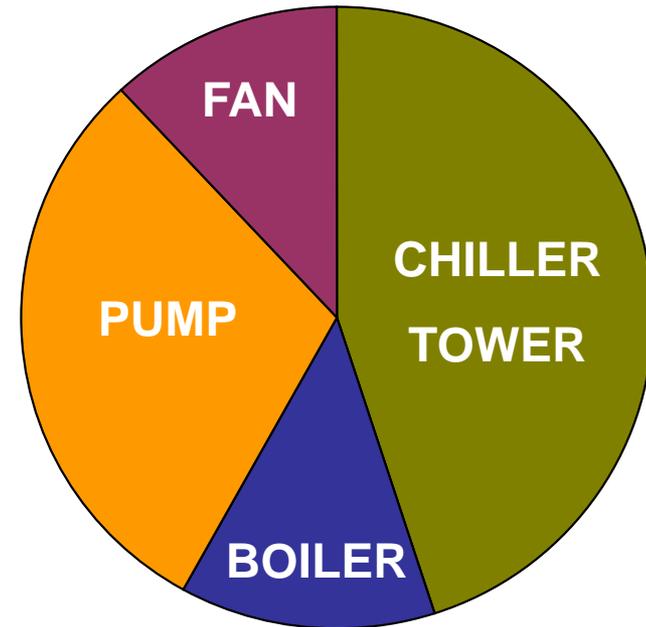
Breakdown:

Chiller / Cooling Tower 45%

Boiler 13%

Pumps 30%

Fans 12%



# THE CHECKLIST

# THE CHECKLIST

## FACTORS AFFECTING ENERGY PERFORMANCE

### Maintenance Items

1. Lighting Controls
2. Filters
3. Fans
4. Pumps
5. Cooling Tower
6. Chillers
7. Boilers
8. Thermostats
9. Humidity Control
10. Night Setback
11. Outside Air Ventilation
12. Economizer Cycle
13. Schedule of Operations



# **FACTORS AFFECTING ENERGY PERFORMANCE**

# FACTORS AFFECTING ENERGY PERFORMANCE

## LIGHTING



“Occupancy Sensor Malfunction”

**Occupancy Sensor Light Control**

**Energy Difference**

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30% overage on light usage due to sensor failure

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+6.8%

# FACTORS AFFECTING ENERGY PERFORMANCE

## LIGHTING

- Lighting usage obviously affects overall building energy performance.
- Lighting also influences energy consumption in other areas....



# FACTORS AFFECTING ENERGY PERFORMANCE

## LIGHTING

Lighting use overage of 30% impacts other systems:

<b>Systems Affected</b>	<b>Energy Difference</b>
HVAC	+1.6%



# FACTORS AFFECTING ENERGY PERFORMANCE

## HVAC EQUIPMENT

“Dirty Filters”

<b>HVAC Equipment</b>	<b>Energy Difference</b>
Dirty filters in AHU's (add 1" static pressure)	+4.1%



# FACTORS AFFECTING ENERGY PERFORMANCE

## HVAC EQUIPMENT

“Fan Speed Malfunction”

<b>HVAC Equipment</b>	<b>Energy Difference</b>
Variable speed fan runs constant volume	+8.4%



# FACTORS AFFECTING ENERGY PERFORMANCE

## HVAC EQUIPMENT

“Pump Speed Malfunction”

HVAC Equipment	Energy Difference
Variable flow pumping runs full speed	+10.6%



# FACTORS AFFECTING ENERGY PERFORMANCE

## HVAC EQUIPMENT

“Dirty Cooling Tower”



<b>HVAC Equipment</b>	<b>Energy Difference</b>
Fouled cooling tower (4 degree rise in condenser water temp)	+1.3%

- *For every 1 degree rise in condenser water temperature, chiller efficiency is lowered approximately 1.5%.*

# FACTORS AFFECTING ENERGY PERFORMANCE

## HVAC SYSTEM TYPES

“Chillers”



<b>Problems</b>	<b>Energy Difference</b>
Fouled tubes	+2.2%
Poor refrigerant charge	+3.7%

Per Brady Trane:

- *Fouled tubes create 10% (or more) loss in chiller efficiency*
- *Poor refrigerant charge (over or under 10%) creates 17% loss in chiller efficiency*

# FACTORS AFFECTING ENERGY PERFORMANCE

## HVAC SYSTEM TYPES



“Boilers”

**Problem**

**Energy Difference**

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93% efficient boiler acting like a 80% boiler

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+4.0%



*Per James M. Pleasants:*

- *“US Department of Interior has established that a half inch of hard water scale-build-up on heat transfer surfaces can add up to 70% fuel costs for that piece of equipment”*

# FACTORS AFFECTING ENERGY PERFORMANCE

## HVAC SYSTEM TYPES

- Maintaining top chiller & boiler efficiency is a big deal.



# FACTORS AFFECTING ENERGY PERFORMANCE

## TEMPERATURE SETPOINTS



“Cooling”



<b>Setpoint</b>	<b>Energy Difference</b>
75 F (base case)	0
72 F	+ 3.0%
78 F	- 2.9%

# FACTORS AFFECTING ENERGY PERFORMANCE

## TEMPERATURE SETPOINTS



“Heating”



<b>Setpoint</b>	<b>Energy Difference</b>
70 F (base case)	0
72 F	+ 0.8%
68 F	- 0.5%

# FACTORS AFFECTING ENERGY PERFORMANCE

## TEMPERATURE SETPOINTS

- “Where the rubber meets the road”.
- Poorly functioning temperature sensors / thermostats affect performance.
- Drifting setpoints problematic



# FACTORS AFFECTING ENERGY PERFORMANCE

## HUMIDITY CONTROL



“Humidity control failure does more than just affect IAQ”

<b>Control Setpoint</b>	<b>Energy Difference</b>
No control	0
60% RH	+ 0.6%
50% RH	+ 2.3%
45% RH	+ 6.6%
40% RH	+17.9%

# FACTORS AFFECTING ENERGY PERFORMANCE

## HUMIDITY CONTROL

- Significant impact on building energy performance.
- Are your humidity setpoints verified and maintained?
- Is your humidity control system operating correctly?



# FACTORS AFFECTING ENERGY PERFORMANCE

## OFF-HOUR SETPOINTS



“What the building does while you sleep”

<b>Night Setback Temperatures</b>	<b>Energy Difference</b>
85 F cooling / 60 F heating (system operational)	0
Setback system failure	+ 6.4%

# FACTORS AFFECTING ENERGY PERFORMANCE

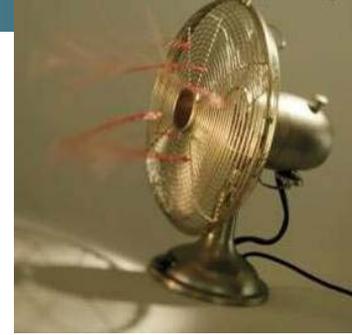
## OFF-HOUR SETPOINTS

- Failure to “dial it down” at night can dramatically affect your energy consumption.



# FACTORS AFFECTING ENERGY PERFORMANCE

## VENTILATION AIR



“Outside Air System Malfunction”

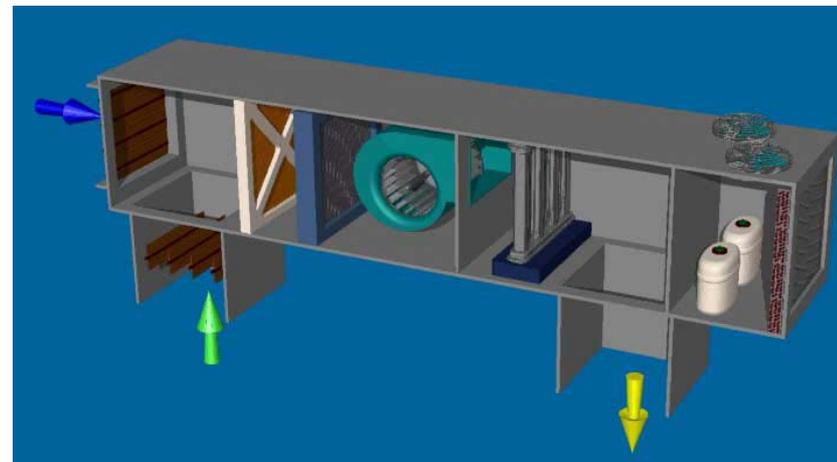
<b>OA Quantity</b>	<b>Energy Difference</b>
50% change from scheduled OA amount	8.2%

# FACTORS AFFECTING ENERGY PERFORMANCE

## VENTILATION AIR

“Demand Control Ventilation”

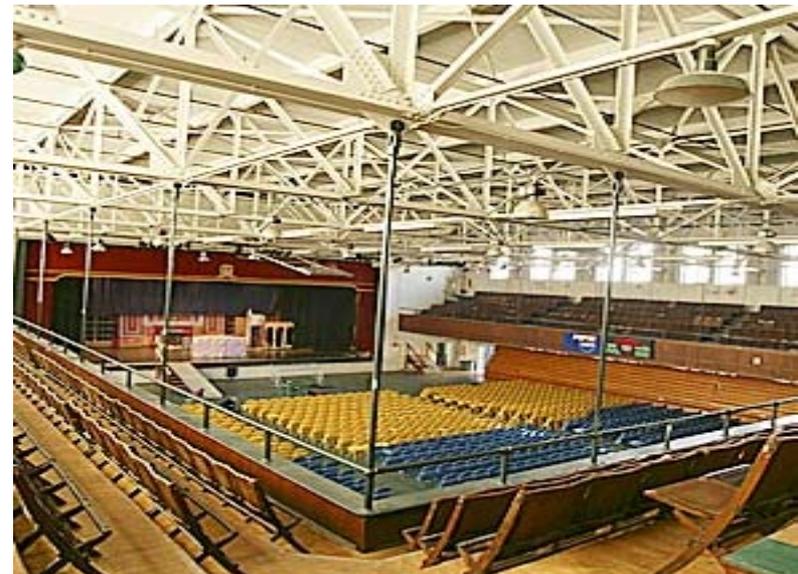
<b>OA Control Type</b>	<b>Energy Difference</b>
CO2 sensor failure (OA levels <u>not</u> reduced)	+2.0%



# FACTORS AFFECTING ENERGY PERFORMANCE

## VENTILATION AIR

- Ventilation system performance significantly affects building energy usage.



# FACTORS AFFECTING ENERGY PERFORMANCE

## AIR-SIDE ECONOMIZER



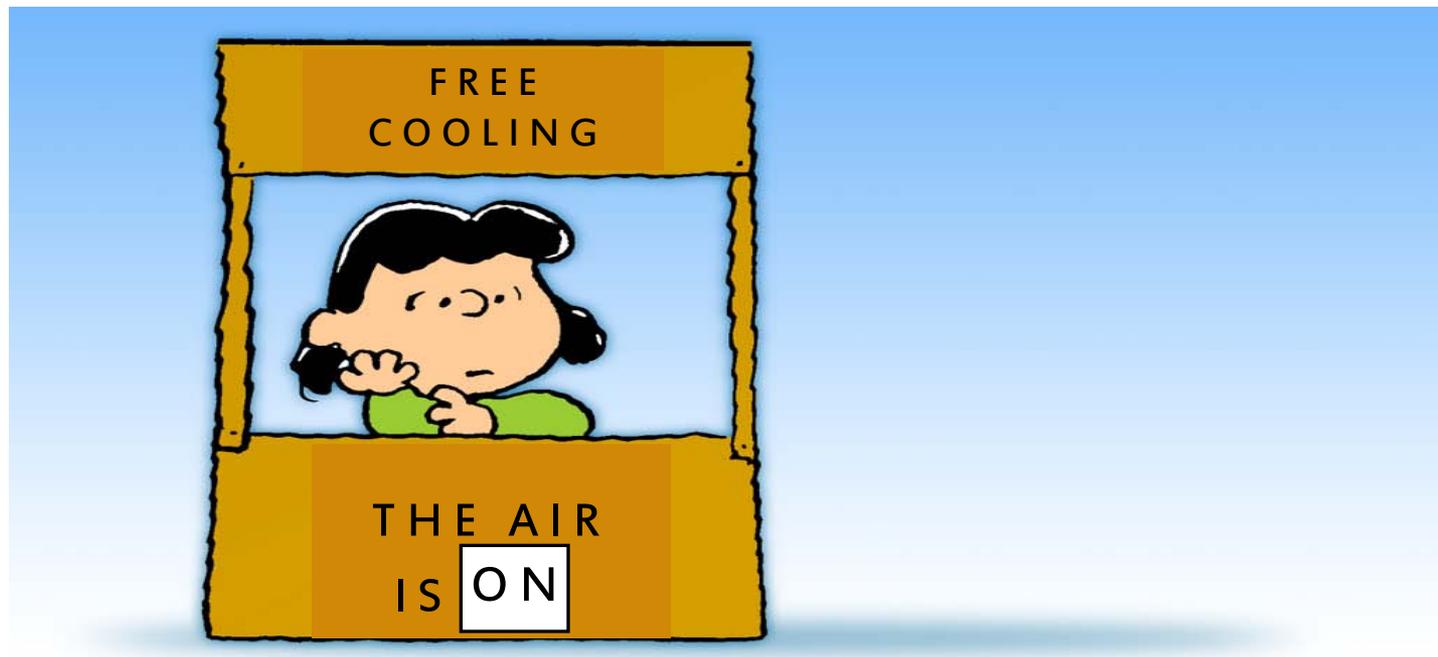
“You can’t save \$ if it doesn’t work”

<b>Economizer Cycle</b>	<b>Energy Difference</b>
Not operational	+1.4%

# FACTORS AFFECTING ENERGY PERFORMANCE

## ECONOMIZER

- Free cooling certainly helps, but only when economizer works.



# FACTORS AFFECTING ENERGY PERFORMANCE

## SCHEDULE OF OPERATIONS

“So what if my time clock is off by an hour...”

**Change In Operations**

**Energy Difference**

One extra hour of building usage (on average)

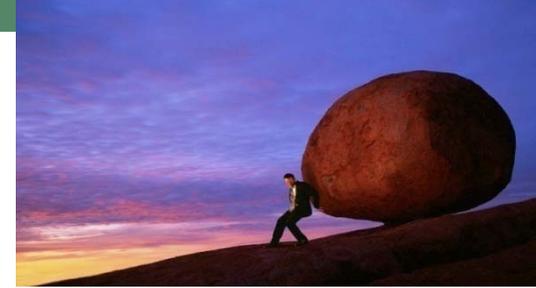
+ 3%

	30 Sunday	1 Monday	2 Tuesday	3 Wednesday	4 Thursday	5 Friday	6 Saturday
						Reading Day	
8:00		Leading Organizations Classroom 150	Decision Analysis Classroom 150	Marketing Classroom 150	Marketing Classroom 150		
9:00							
10:00		Decision Analysis Classroom 150	Accounting Classroom 150	Operations Classroom 150	Operations Classroom 150		Darden Cup: Soccer The Park
11:00						Innovation Challenge	
12 pm		Accounting Classroom 150	Leading Organizations Classroom 150	Leading Organizations Classroom 150	Career Management Classroom 150		
1:00	Innovation Challenge:	Monday's with the Dea	Leadership Speaker S Abbott Center	Bain Q&A - Internship;	Marketbridge Compan Saunders Hall		
2:00							
3:00				Innovation Challenge;			
4:00						Learning Team Room 275	
5:00		Innovation Challenge;	Reception with Dean E Wilkinson Courtyard				
6:00		EVC Speaker Series: R					
7:00	Learning Team (Dinner) Ryan's House	Learning Team Room 275		General Motors Comp;	Cold Call and Screen on the Green	IBM Comp;	
8:00			Learning Team Room 275	Learning Team Room 275			
9:00						Dinner with Ambrosini's and Liang's Ivy Gardens	
10:00							

# **WORSE CASE SCENARIO**

# WORSE CASE SCENARIO

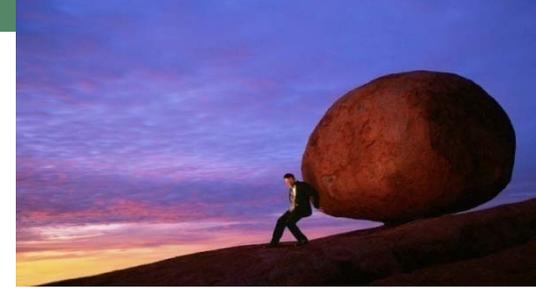
## OPERATION COMPARISON



	<b>Best Case</b>	<b>Worse Case</b>
Light Sensor	OK	30% overage
Filters	Clean	Very Dirty
Fans	Variable Speed	Full Speed
Pumps	Variable Speed	Full Speed
Cooling Tower	OK	Fouled
Chiller	OK	Fouled, Poor Charge
Boiler	OK	Efficiency Loss

# WORSE CASE SCENARIO

## OPERATION COMPARISON



	<b>Best Case</b>	<b>Worse Case</b>
Thermostats	OK	3F drift
Humidity	50%	40%
Night Setback	OK	Disabled
Outside Air	OK	50% overage, no demand
Economizer	OK	Disabled
Schedule	OK	1 hour off

**Energy**

**\$ 164,000**

**\$ 297,852**

**81.4 % increase**

# SUMMARY

## SUMMARY

### DEFERRED MAINTENANCE IMPACT

#### Annual Effect on Energy Cost

##### 1 – 5%

- Dirty filters
- Fouled cooling tower
- Boiler efficiency loss
- T'stat setpoint drift
- Economizer
- Schedule

##### 5+%

- Lighting control
- No fan speed control
- No pump speed control
- Chiller fouled & mischarged
- Humidity control
- Night set back
- OA ventilation rate overage



## CONCLUSION

### **“THE COST OF DOING NOTHING”**

- Maintainable systems (mechanical & electrical) use approximately 75% of building energy
- Ignoring maintenance of building systems can increase energy usage significantly



**THANK YOU FOR YOUR TIME**