PURDUE
UNIVERSITY

MANUFACTURING EXTENSION PARTNERSHIP

MISSION: TO ADVANCE ECONOMIC PROSPERITY, HEALTH AND QUALITY OF LIFE IN INDIANA AND BEYOND.

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BEYOND THE LOW HANGING FRUIT

ENERGY EFFICIENCY GAINS FOR ADVANCED COMPANIES

AGENDA

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Energy Basics

Systems Approach

Maintenance

Soft Benefits of Green Building

New Technologies

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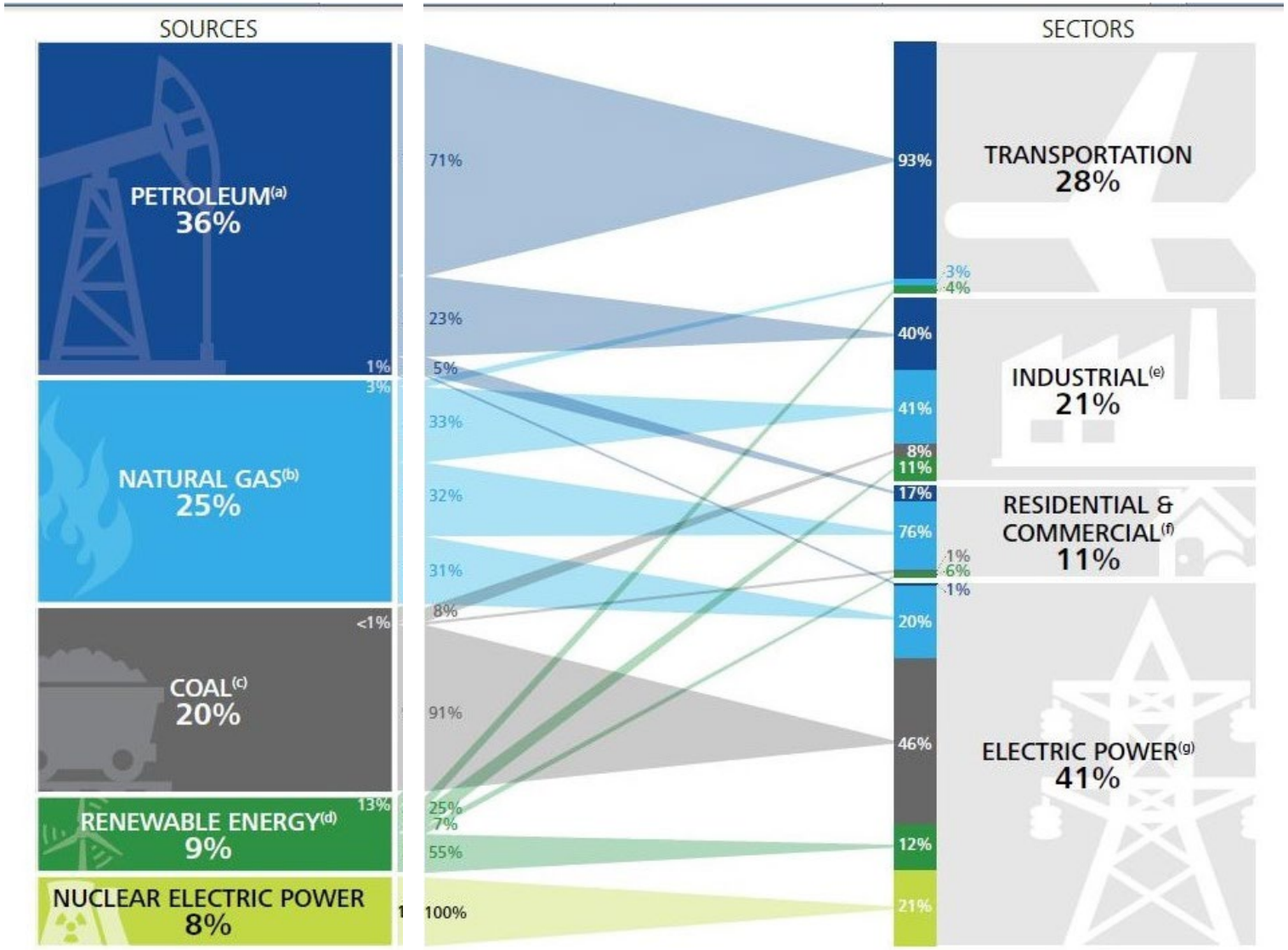
WHERE ENERGY GETS USED



Source: Terzic, Branko. 2011. “Energy Independence and Security: A Reality Check.” Deloitte University Press.

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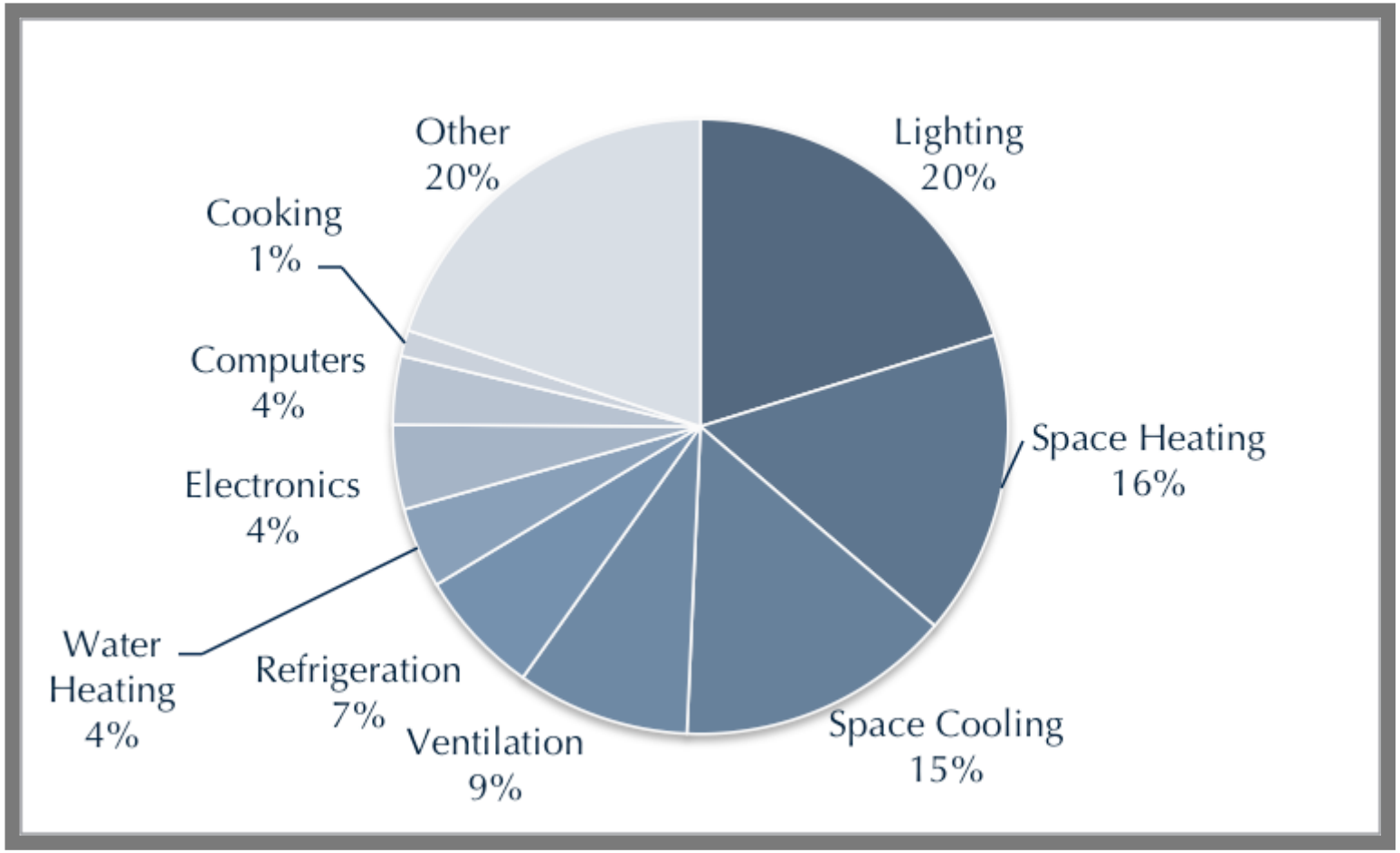
COMMERCIAL ENERGY CONSUMPTION



Source: DOE, 2011. Buildings Data Book

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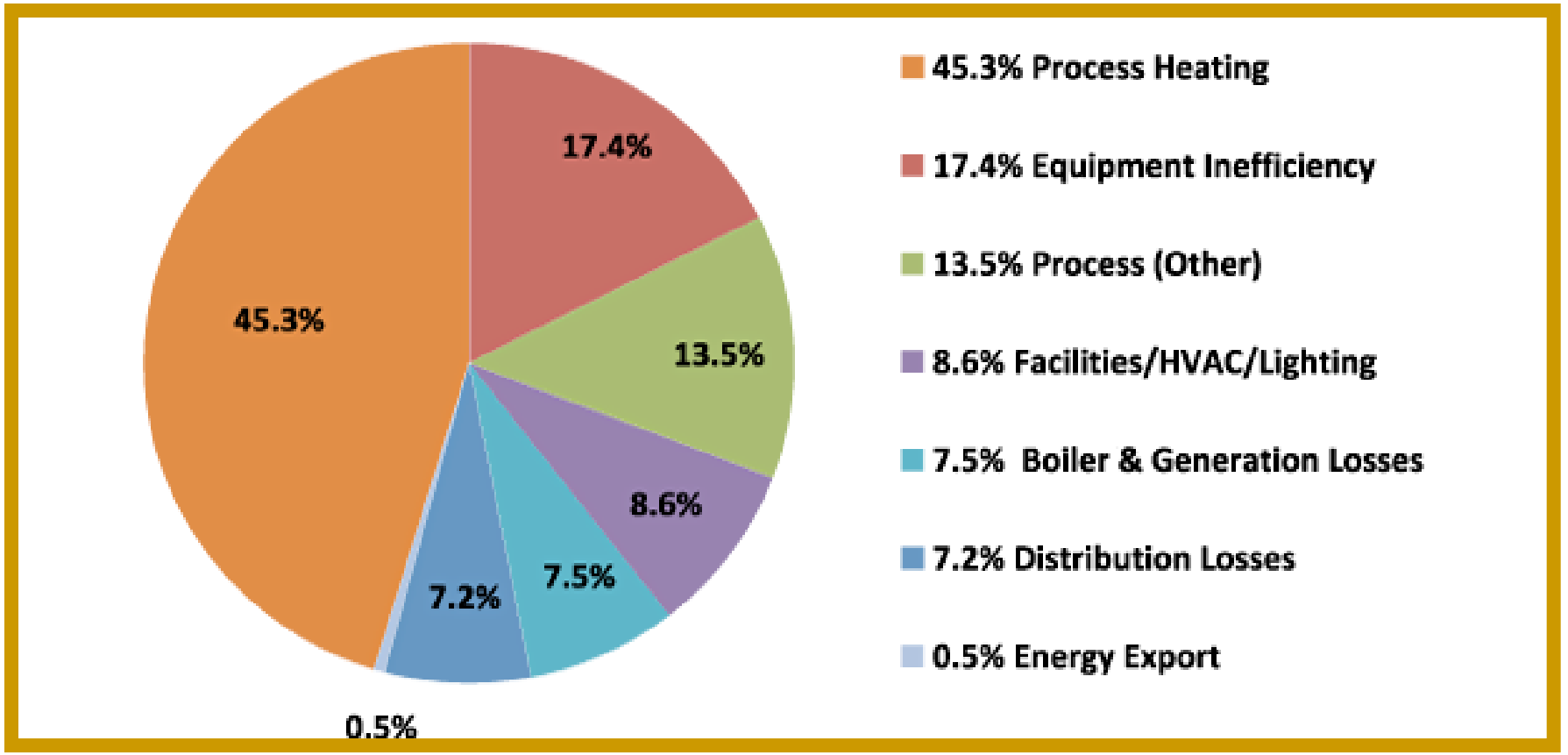
INDUSTRIAL ENERGY CONSUMPTION



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EASY ENERGY EFFICIENCY

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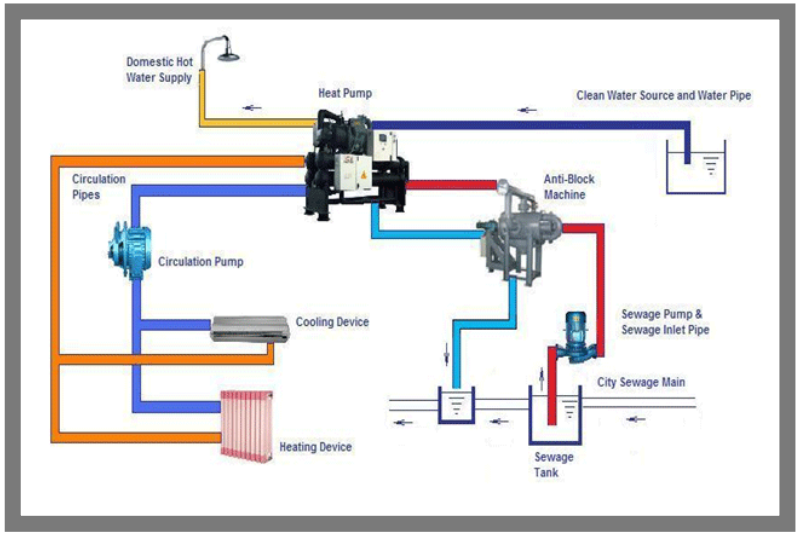
IMPORTANCE OF A SYSTEMS APPROACH

Looking beyond individual components -- looking at the *system as a whole*

- Boiler vs. Steam *System*
- First Cost vs. *Life Cycle* Costs
- Pump vs. Water Pumping *System*



SYSTEM LIFE CYCLE COST COMPONENTS

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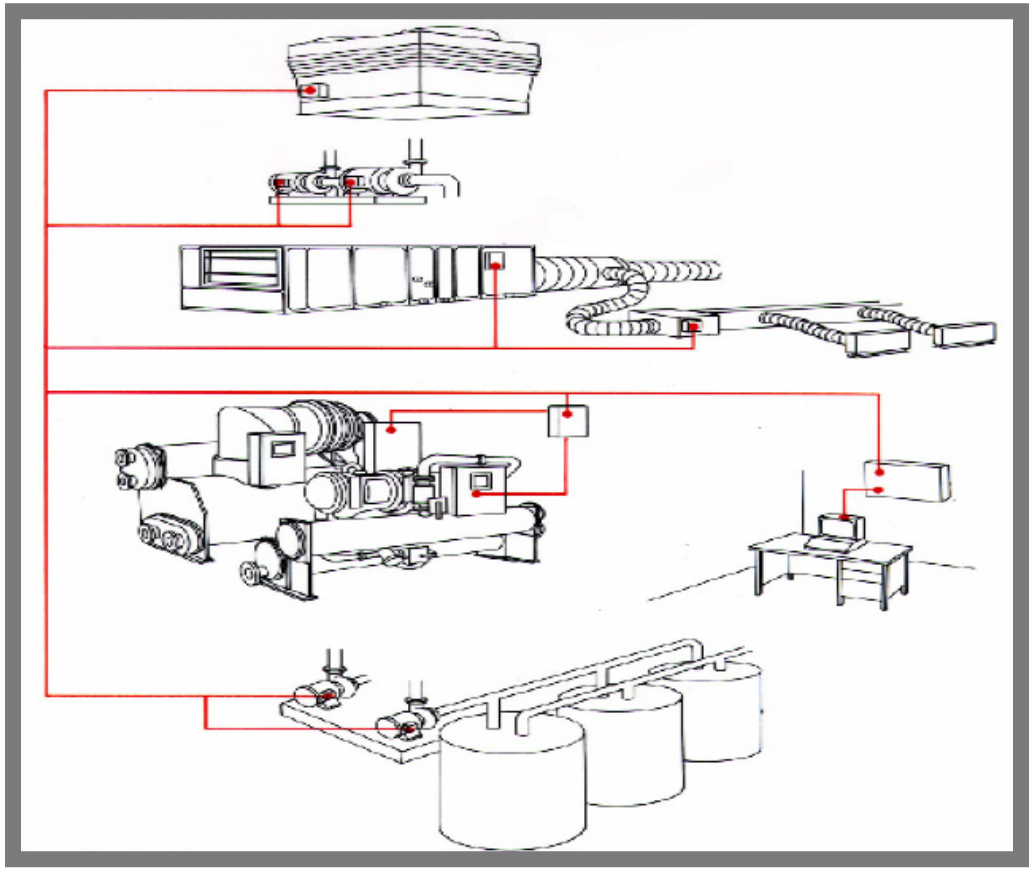

What are the system costs of an HVAC system?

LIFE CYCLE COST COMPONENTS

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1. **Installation Costs**

- ❑ Capital expenditure
- ❑ Expenses
- ❑ Labor
- ❑ Materials
- ❑ Engineering

LIFE CYCLE COST COMPONENTS

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2. Energy Costs

Based on:

- ❑ Efficiency
- ❑ Operating hours
- ❑ Electricity rates

Up to 8 times larger than installation cost

LIFE CYCLE COST COMPONENTS

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3. **Maintenance Cost**

Typically between 5% to 10% of installation cost *annually*

LIFE CYCLE COST COMPONENTS

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4. Lost Production Cost

- ❑ Lost sales & opportunities
- ❑ Overtime
- ❑ Late shipping charges
- ❑ Domino effect on just-in-time supply chains

STORY PROBLEM: FOUR NEW FANS

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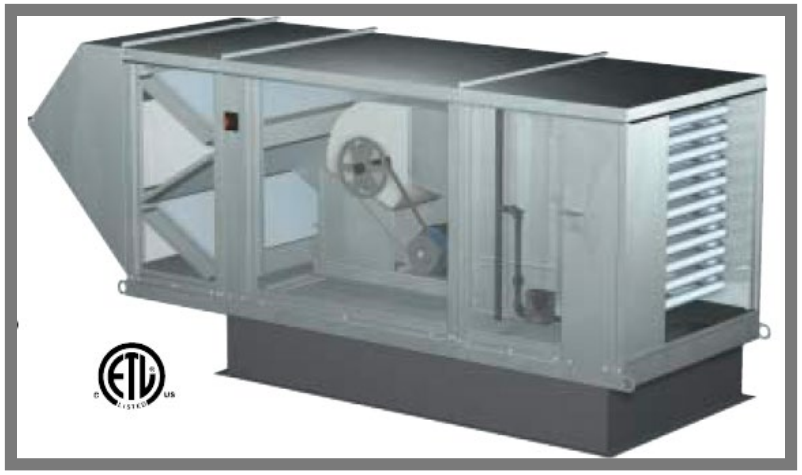
Story Problem # 1

Situation: Four fans in an HVAC system need to be replaced



Two options. Which is more cost effective?

STORY PROBLEM: FOUR NEW FANS

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Option #1:

50 hp radial fans with flat blades
Total installation cost = $70,000
Fan efficiency = 55%
Resultant annual energy cost = $48,000
Annual Preventive Maintenance Cost = $1,000

Option #2:

40 hp radial fans with airfoil blades
Total installation cost = $105,000
Fan efficiency = 85%
Resultant annual energy cost = $30,000
Annual Preventive Maintenance Cost = $1,000

A SIMPLE SYSTEM COST ANALYSIS

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System Costs		Option 1	Option 2
Installation Costs (occurs in Year 1)	A	$70,000	$105,000
1. Preventative Maintenance (recurring annual cost)	1	$1,000	$1,000
2. Predictive Maintenance (recurring annual cost)	2		
3. Energy (recurring annual cost)	3	$48,000	$30,000
4. Lost Production (recurring annual cost)	4		
Annual Cost	B = (1+2+3+4)	$49,000	$31,000
Cumulative Outlay end Year 1	=A+B	$119,000	$136,000
Cumulative Outlay end Year 2	= A+B+B	$168,000	$167,000

CASH FLOW - YEARS 1-5

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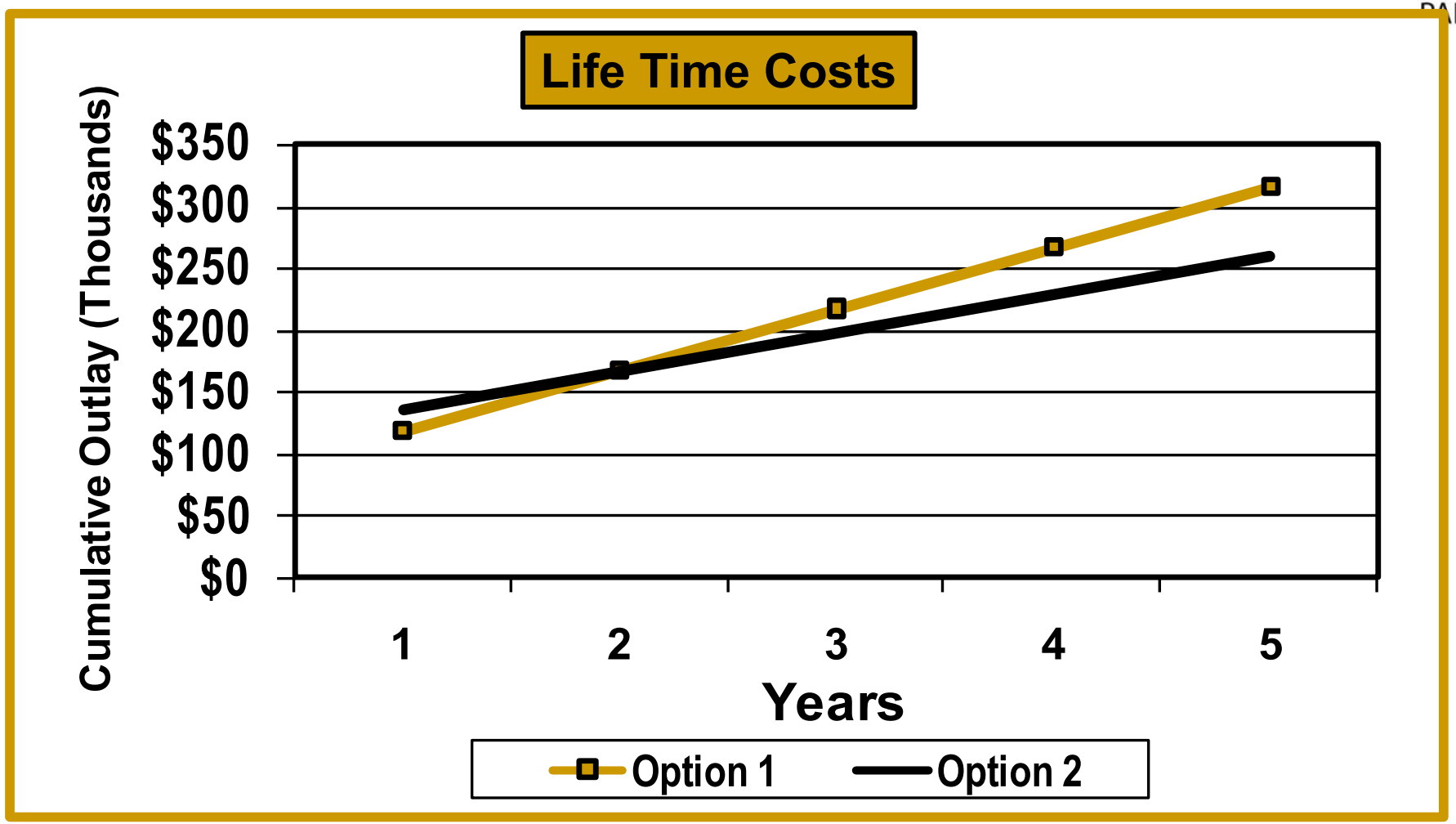
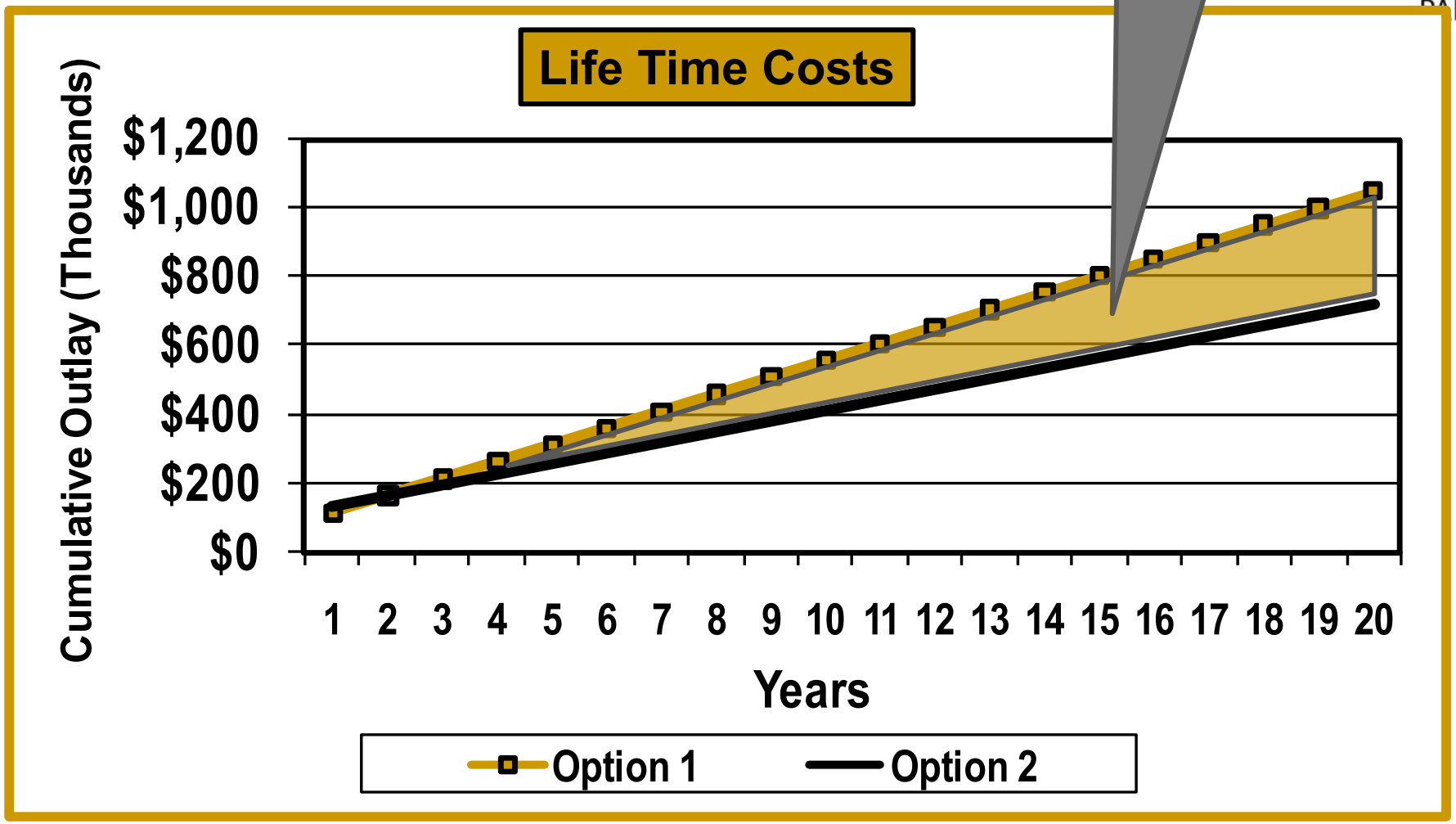


CUMULATIVE CASH FLOW



OVERALL SYSTEM COSTS OF OPTIONS

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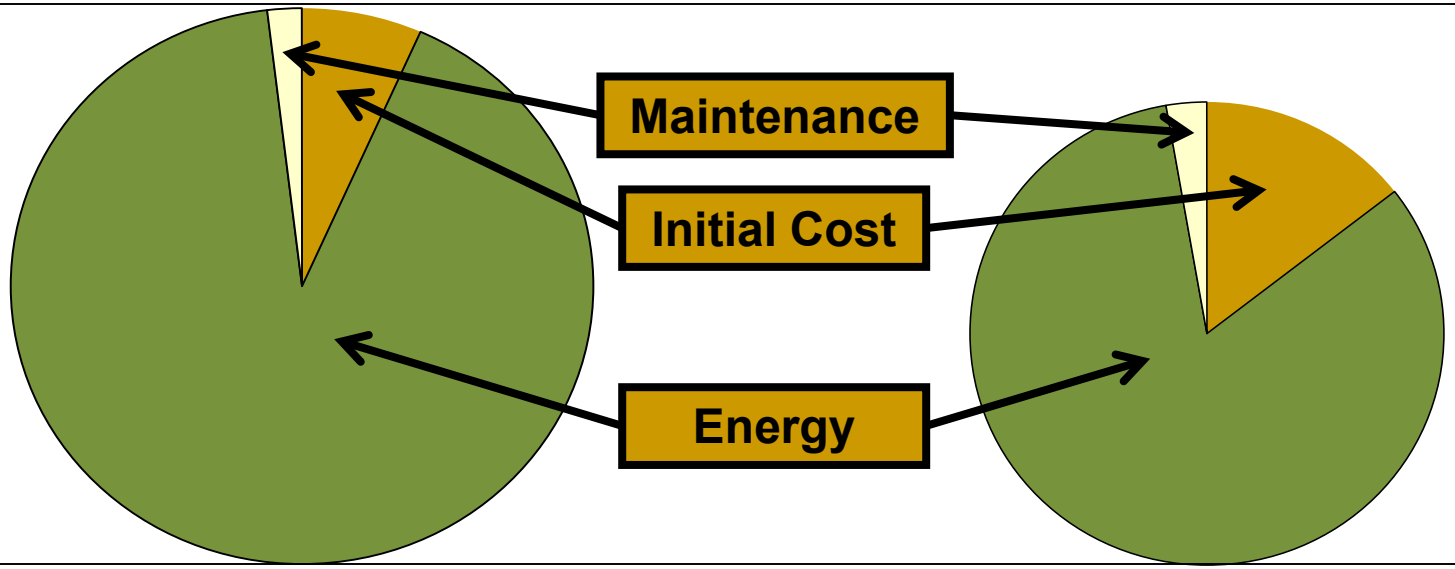
Option #1: Radial Fan	Option #2: Airfoil Fan



Lifetime Cost	Lifetime Cost
$1,050,000	$725,000

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GOOD MAINTENANCE SAVES COSTS

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- Preventive
- Predictive

PREVENTIVE MAINTENANCE

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Strategies **to keep a healthy machine in peak performance include:**

Lubricating bearings

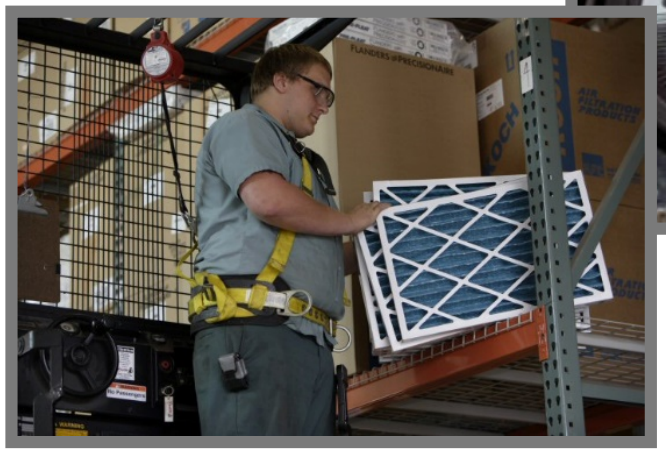
Cleaning impellers and heat exchangers

Aligning shaft and pulleys

Visually inspecting machinery

Balancing impeller

PREVENTIVE MAINTENANCE



Replacing filters

Maintaining electrical specifications

Adjusting linkages of valves/dampers

Verifying correct operation of dampers, valves, controls, automatic drains, and steam traps

PREDICTIVE MAINTENANCE

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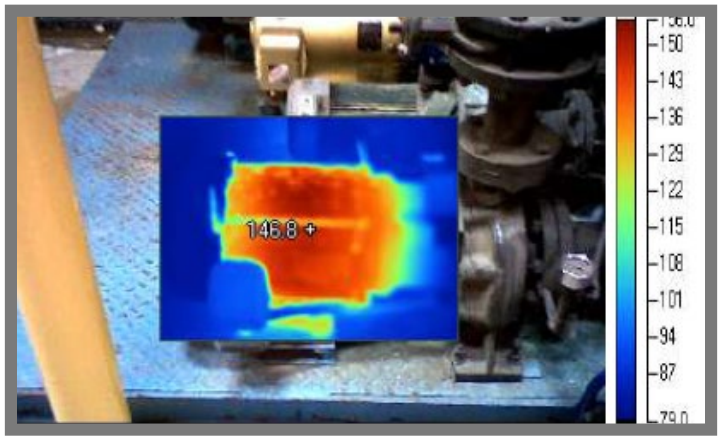
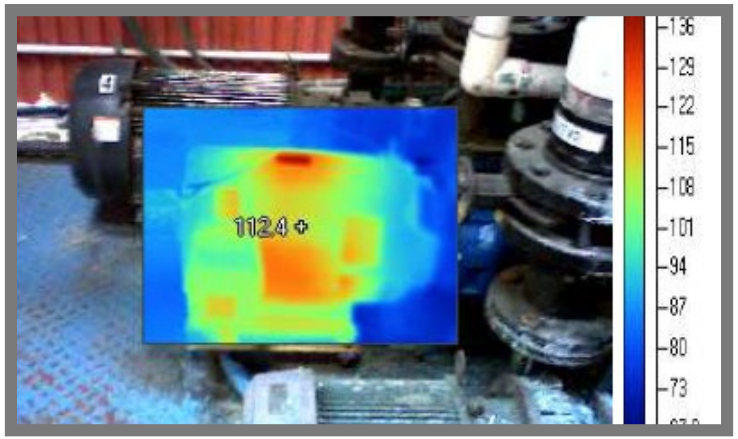
Advanced diagnostic strategies that can avoid an impending breakdown:

- **Infrared thermography of fan or motor bearings**
- **Check strength of wiring insulation**
- **Dynamic analysis of the integrity of a motor**



Normal Efficiency



High Efficiency

PREDICTIVE MAINTENANCE

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✓ **LOW-COST & NO-COST ACTIONS**

IR inspection electrical panels

Vibration analysis of motors

Oil analysis on compressors

DOES MAINTENANCE MATTER?

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Story Problem #2

Option #1: **An induced draft fan that receives basic preventive maintenance.**

Versus

Option #2: **An induced draft fan that receives predictive maintenance plus more frequent preventive maintenance.**

DOES MAINTENANCE MATTER?

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Option #1:

An induced draft fan that costs $40,000/year to operate serves a boiler. Twice a year, it receives the following **preventive maintenance**:

- The bearings are greased
- The motor is cleaned
- The bearings in the dampers are greased

Last year, the fan broke down due to a **bearing failure**. This breakdown caused a **five- hour production outage**. Lost production cost **$10,000/hour**. Similar outages are anticipated every two years unless something changes.

The cost of the preventive maintenance is **$500 twice a year.**

DOES MAINTENANCE MATTER?

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Option #2:

An induced draft fan that costs $40,000/year to operate serves a boiler. Three times a year, it receives the following **preventive maintenance:**

- The bearings are greased
- The motor is cleaned
- The bearings in the dampers are greased

It receives the following **predictive maintenance:**

- The bearings are monitored for vibration once a month
- The electrical supply is checked every other year

Last year, vibration monitoring picked up a faulty bearing, which maintenance was able to change out during a brief planned outage. A **failure was avoided**, so there was no lost production time.

Two years ago, a check of the electrical supply found that one of the connections in the electrical panel had worked itself loose and was causing a voltage unbalance. The situation was corrected before the motor sustained any damage.

The cost of the preventive maintenance is **$500 three times a year**.

The cost of the predictive maintenance includes **$200 every month** for vibration monitoring and **$500 every other year** to check the electrical supply.

DOES MAINTENANCE MATTER?

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Life Cycle Cost Analysis		Option 1	Option 2
Installation Costs (occurs in Year 1)	A	N/A	N/A
1. Preventative Maintenance (recurring annual cost)	1	$1,000	$1,500
2. Predictive Maintenance (recurring annual cost)	2	$ 0	$2,650
3. Energy (recurring annual cost)	3	$40,000	$40,000
4. Lost Production (recurring annual cost)	4	$25,000	$ 0
Annual Cost	B = (1+2+3+4)	$66,000	$44,150
Cumulative Outlay end Year 1	=A+B	$66,000	$44,150
Cumulative Outlay end Year 2	= A+B+B	$132,000	$88,300

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New Technologies

PRODUCTIVITY IMPROVEMENTS

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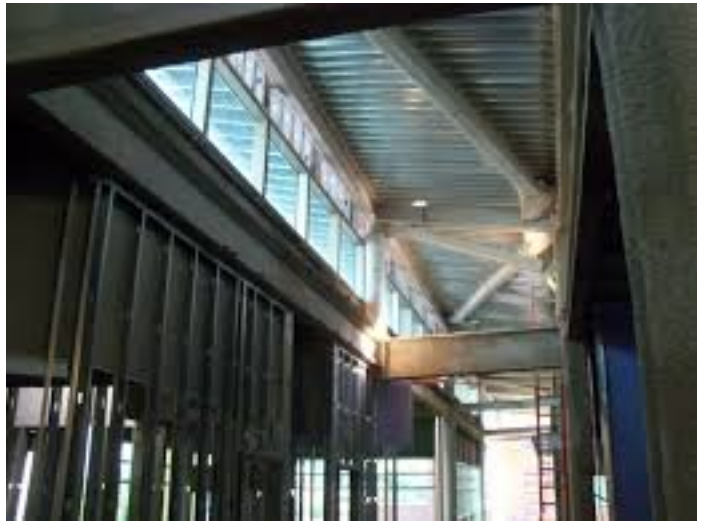
- More rigorous environmental standards = **16% higher** labor productivity
- Workers with a view performed 10% to 25% better on tests of mental function and memory recall

HR COSTS



- Labor is typically the 1st or 2nd largest cost for companies.
- Companies with sustainability goals have higher employee rentention, better recruitment, & reduced turnover.
- Reduced turnover means less time working understaffed, searching for talent, training, and bringing productivity back to 100%.

HEALTHIER BUILDINGS

In terms of health care costs,

building retrofits which improved the indoor environment of a building resulted in reductions of:

- Communicable respiratory diseases of 9-20% less;
- Allergies and asthma of 18-25% less;
- Non-specific health and discomfort effects of 20-50% less.

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HEALTHIER LIGHTING

Light influences how **productive** we are at work, how well we learn, and how quickly we **recover** from illness.

New products promote health – usually by adjusting the brightness and color of the light during the day to mimic natural light.

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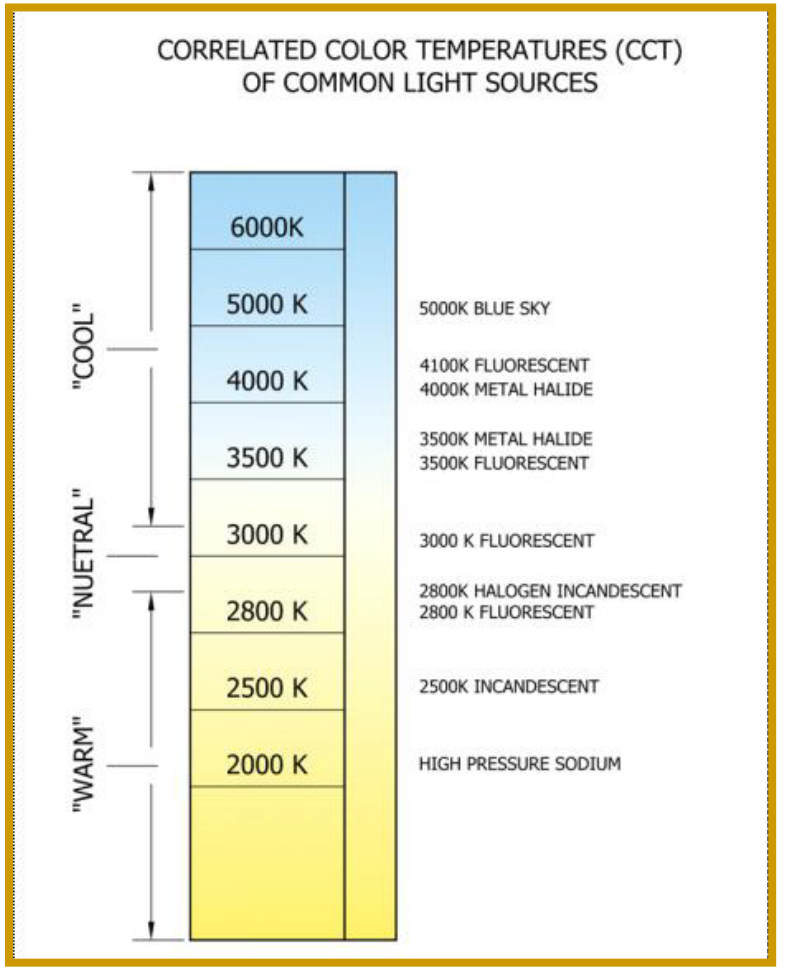
COLOR TEMPERATURE (CCT)



COLOR TEMPERATURE

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IHG Brand hotels launched pilot of new “human-centric lighting” in 2019.

Tuned LED colors enable better circadian rhythm syncing for better quality sleep.

IHG
InterContinental Hotels Group

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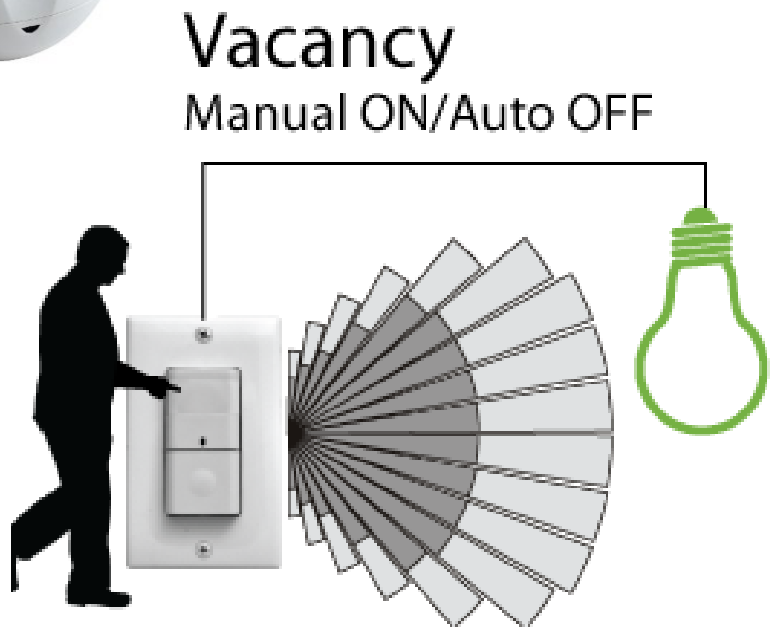
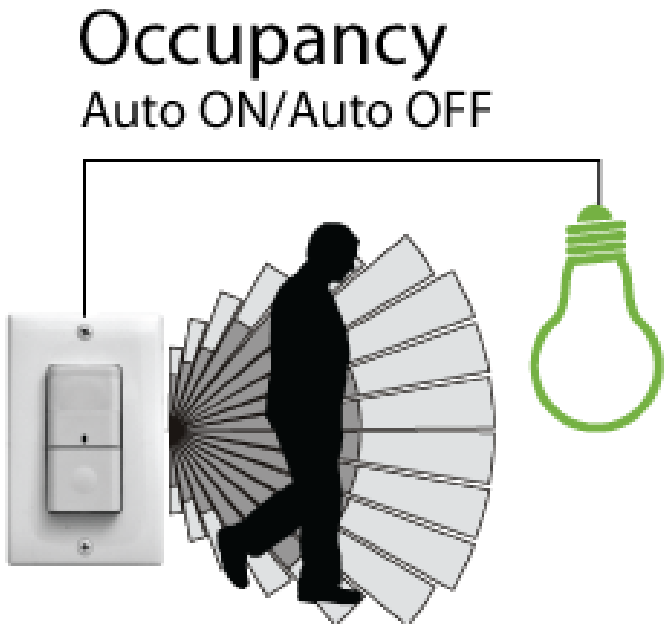
AUTOMATED CONTROL SYSTEMS





WIRELESS CONTROL SYSTEMS

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WIRELESS CONTROL SYSTEMS

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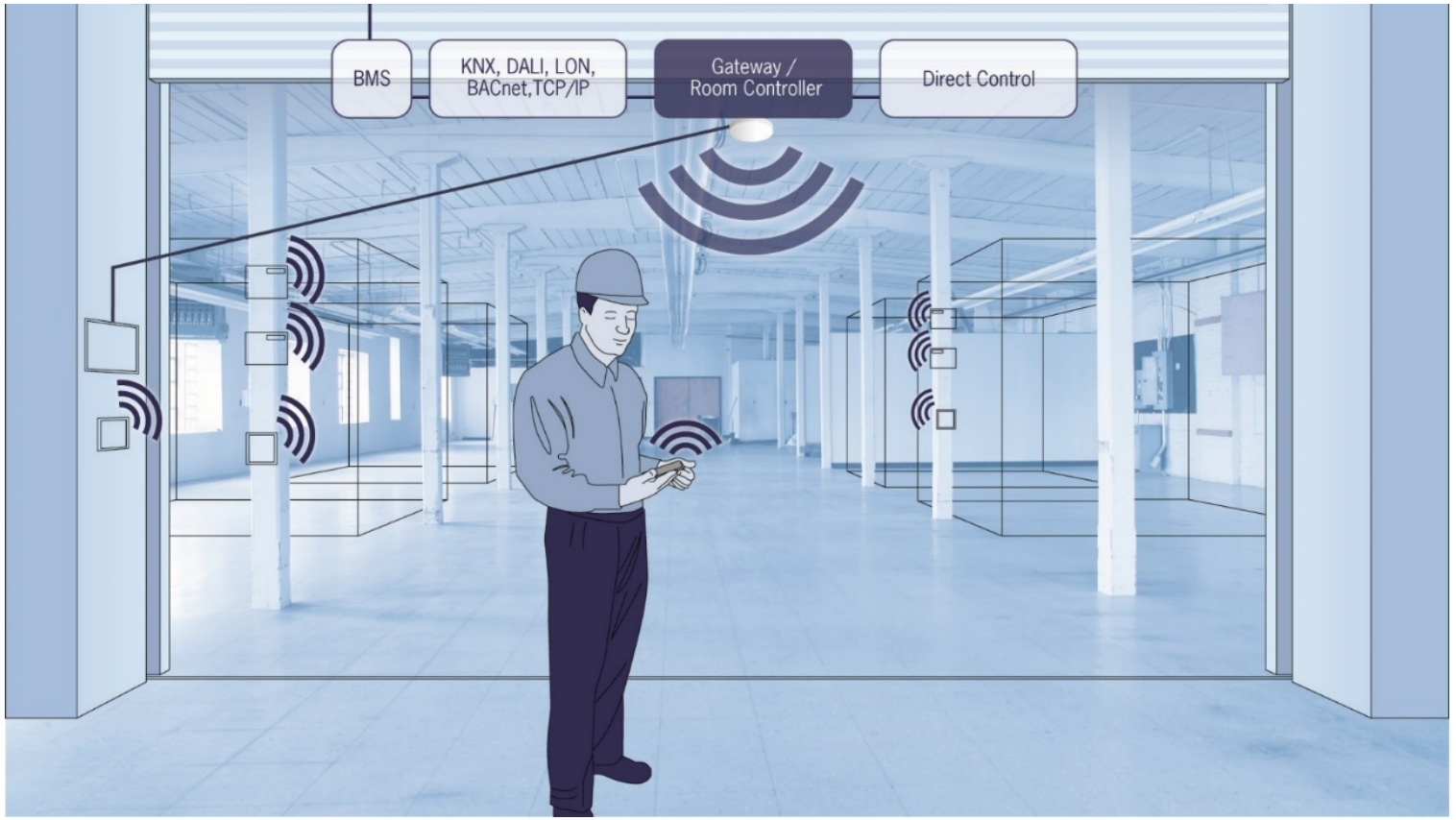

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WIRELESS CONTROL SYSTEMS

- Easy to retrofit
- Create new zones using existing junction boxes
- One power pack can control multiple fixtures
- Dimmable
- Works with fluorescent or LED
- Integrate daylight harvesting

WIRELESS CONTROL SYSTEMS

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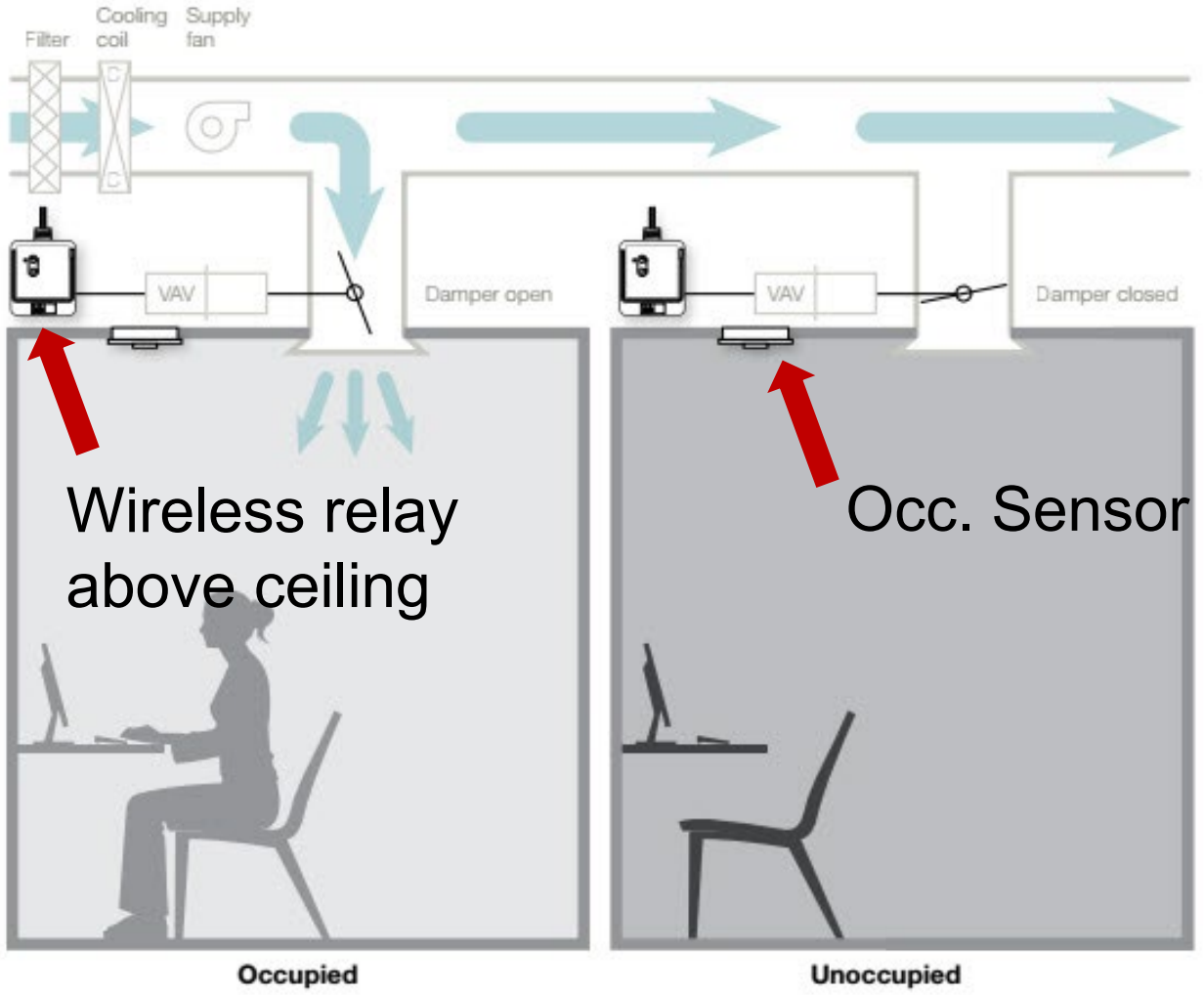
Control HVAC w/ occ. sensor



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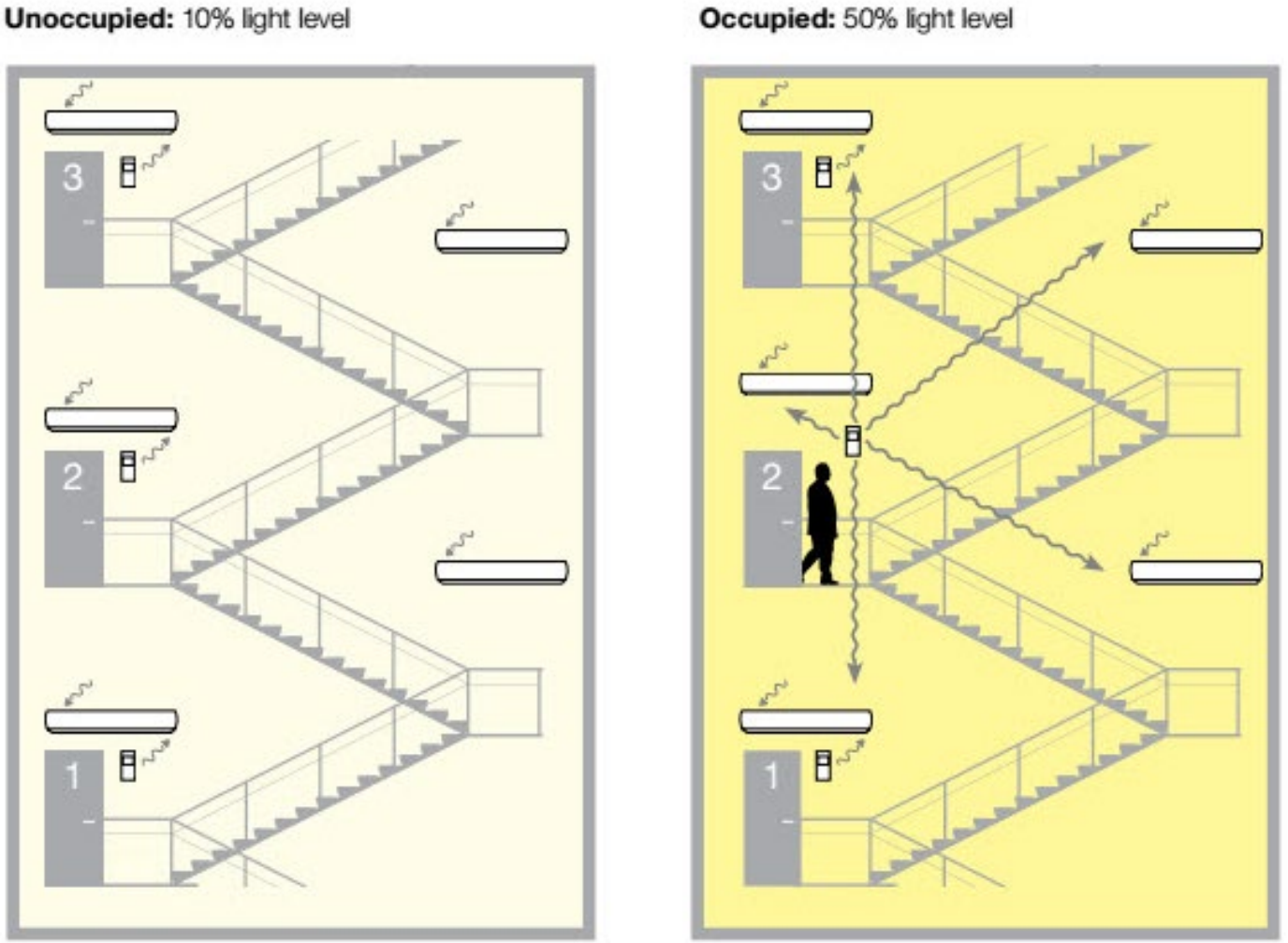
WIRELESS STAIRWELL SOLUTION

ALL lights automatically brighten when sensor indicates a person has entered.

ALL lights stay on until person has exited.

Adjustable dimmability.



INSTANT-FIT LED RETROFITS

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- Plug 'n play solution
- No rewiring
- Leave your existing electronic ballast
- 2100 Lumens
- 4000K
- 17-Watt

DRIVER-LESS LEDS

- Drivers are often the first component of a lighting system to fail
- Power system for lighting using a central hub, with each fitting connected directly to a bus cable.
- The latest innovation is power-over-Ethernet, which provides electricity through data cables.

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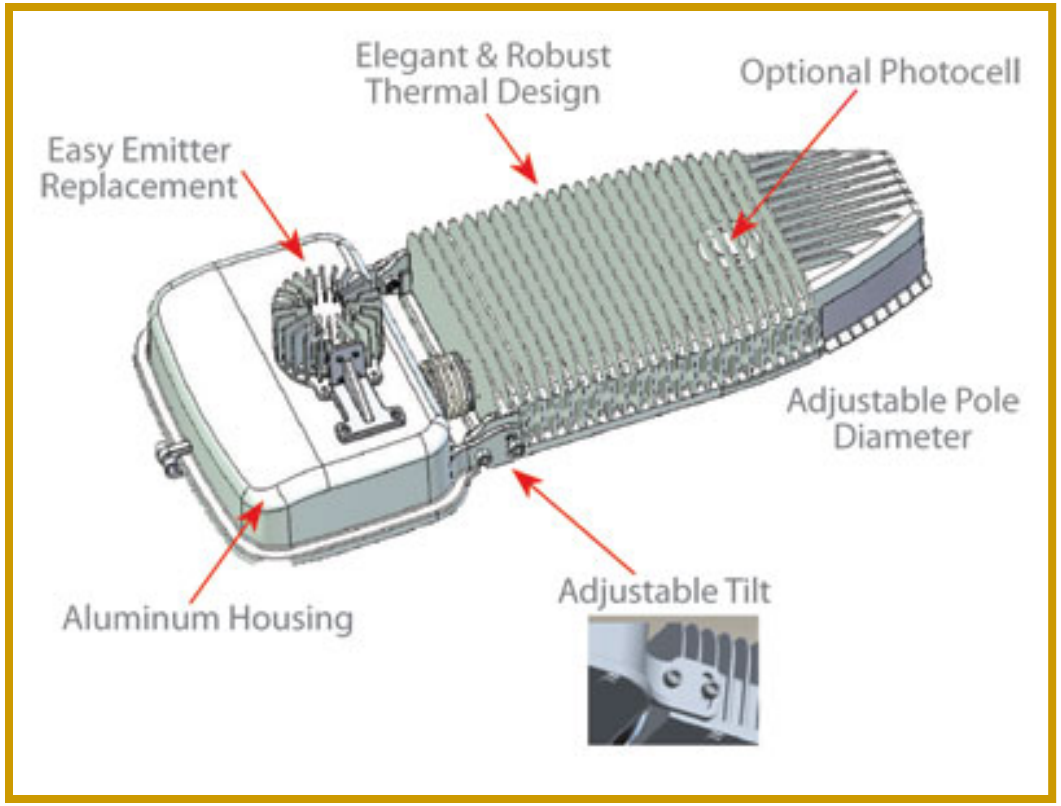
PLASMA LAMPS



No electrode

Long life

Good efficacy

Good CRI

Compact beam

PLASMA STREETLIGHT RETROFITS

- 600 LEP-based street lights installed in Scottsburg, IN
- Chose LEP based on its "brighter output, exceptional color quality, greater energy savings, and long life."
- Projects $70,000 in annual energy savings – in part due to the fact that the LEP lights can be dimmed down to 20% of full brightness.
- Rated for a 50,000-hour life.

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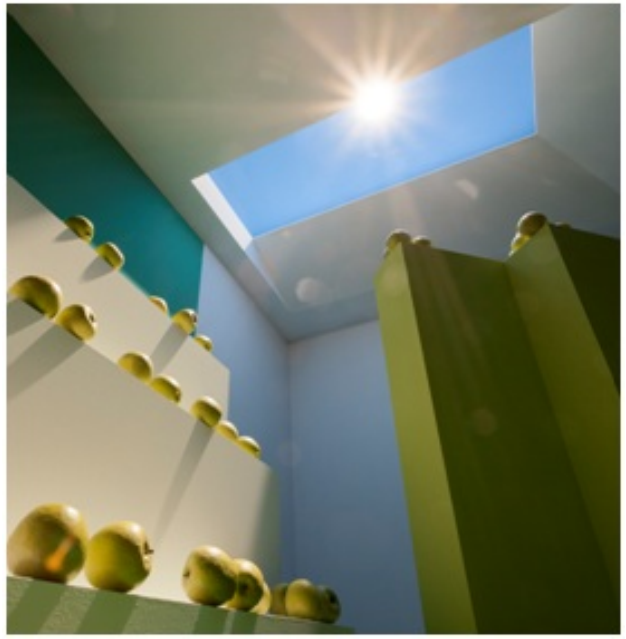
LED SKYLIGHTS



GRAPHENE LED

- Discovered in 2004, Graphene is a transparent electrode material that is ideal for use in electrical and optical devices.
- High conductivity = brighter, longer-lasting and more efficient sources
- No self-heating issue because of graphene's ability to spread heat and reduce thermal boundary resistance.

FOR MORE INFORMATION:

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