# WASBO
# Summer Midwest Facility Masters Conference

## Understanding HVAC

### Presenters:

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Illingworth-Kilgust Mechanical

**June 11, 2021**
**10:25am – 11:15am**

# Types of Commercial Systems

## Common HVAC Systems:

- Rooftop Units, AHUs (Packaged Units)
- Heat Pumps (Air & Water Source)
- Boilers (Hot Water & Steam)
- Chillers (Air Cooled, Water Cooled, Glycol Cooled)
- Cooling Towers
- Heaters (Gas fired, Electric, Hot Water, Infra-Red etc.)
- Fans and Ventilation

# Types of Commercial Systems

## Most commercial buildings have Packaged Rooftop Units

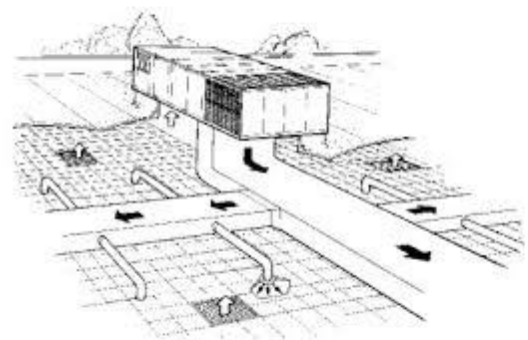
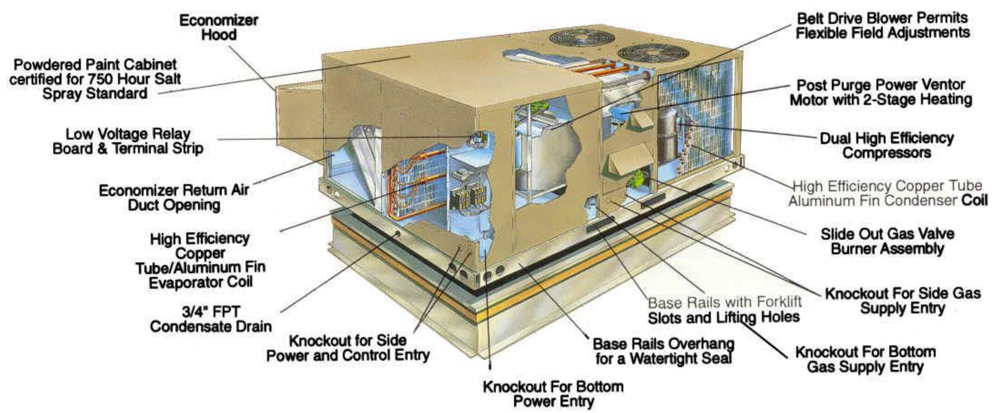


FIGURE 5.13 Typical rooftop installation of the single-zone system. (Lennox)

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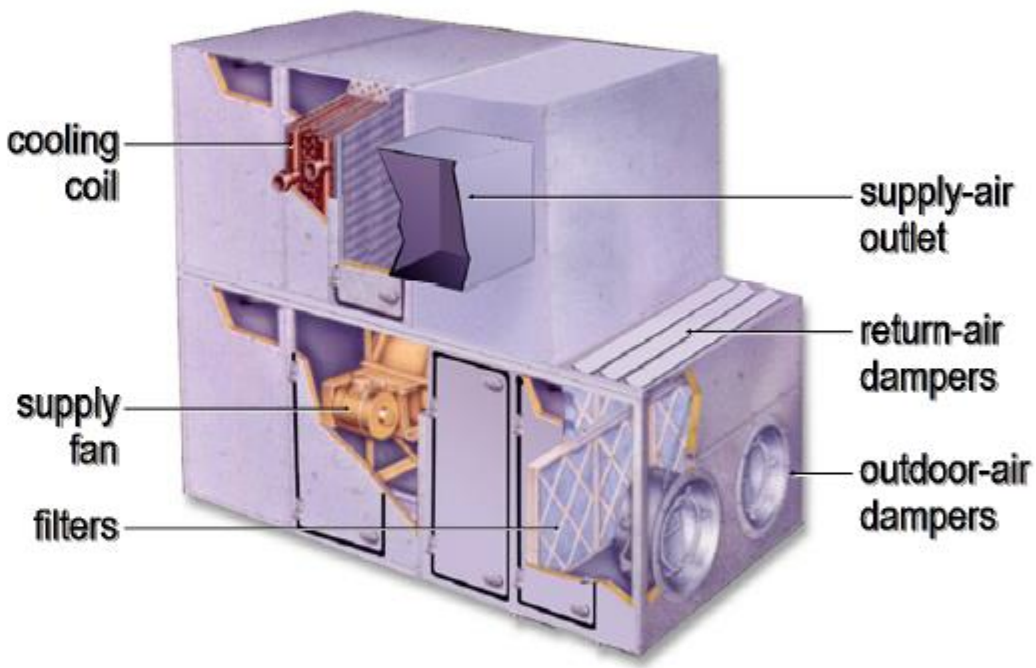
# Types of Commercial Systems

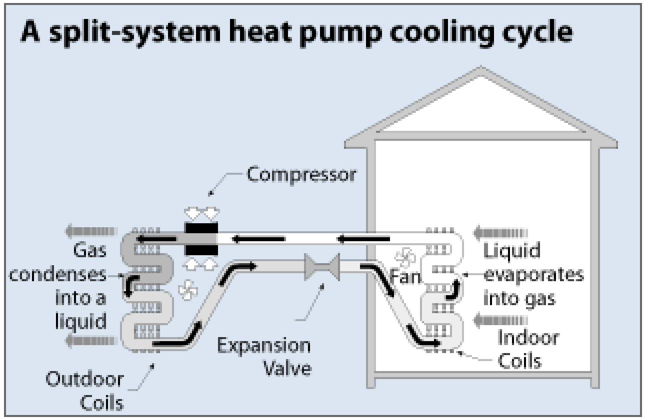
Just as the compressor is the workhorse of an HVACR refrigeration system, the **Air Handling Unit** (**AHU**) is the heart of an HVACR air distribution and ventilation system.

## Air Handling Unit



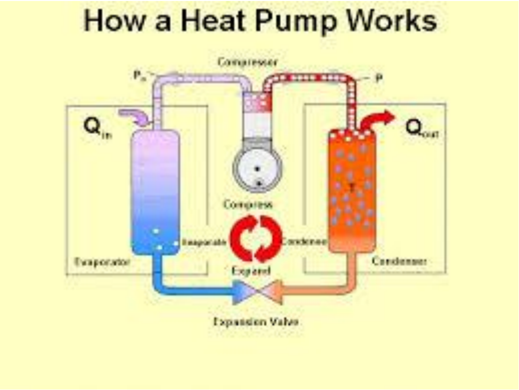
# Types of Commercial Systems

**Heat Pumps:** Like a refrigerator working in reverse, a heat pump extracts the heat from the air (or water) and uses it for heating. The most common air-to-air heat pumps have the compressor and condenser in an outside unit. Then the refrigerant piping goes to an inside air handler unit which houses the expansion valve and the evaporator. System simplicity and low initial cost are the main benefit, while short life span (7 years is typical) and lack of control options are the principal drawbacks.



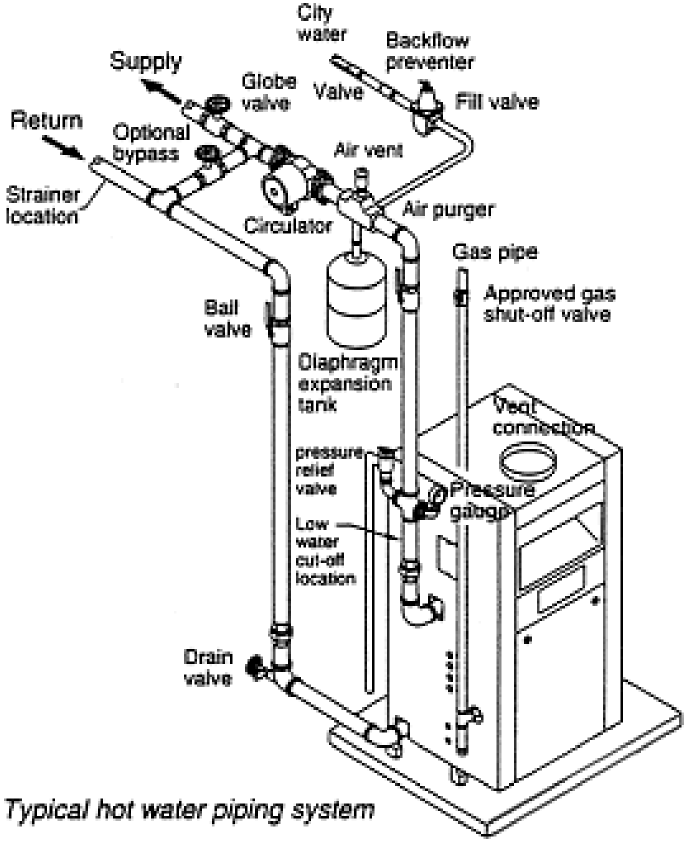
# Types of Commercial Systems

**Water Source Heat Pumps:** Called a one pipe system, a single pipe carries water through the building which the individual water source heat pumps use for their heat source.  This system requires a boiler to raise the loop water temperature and a cooling tower to lower the loop water temperature. Each zone has a dedicated water source heat pump that is located inside the building. This system is extremely energy efficient during those times of the year. The main drawback is probably all the compressors located throughout the interior, both for noise and maintenance.



# Types of Commercial Systems

## Boilers (Hot Water)

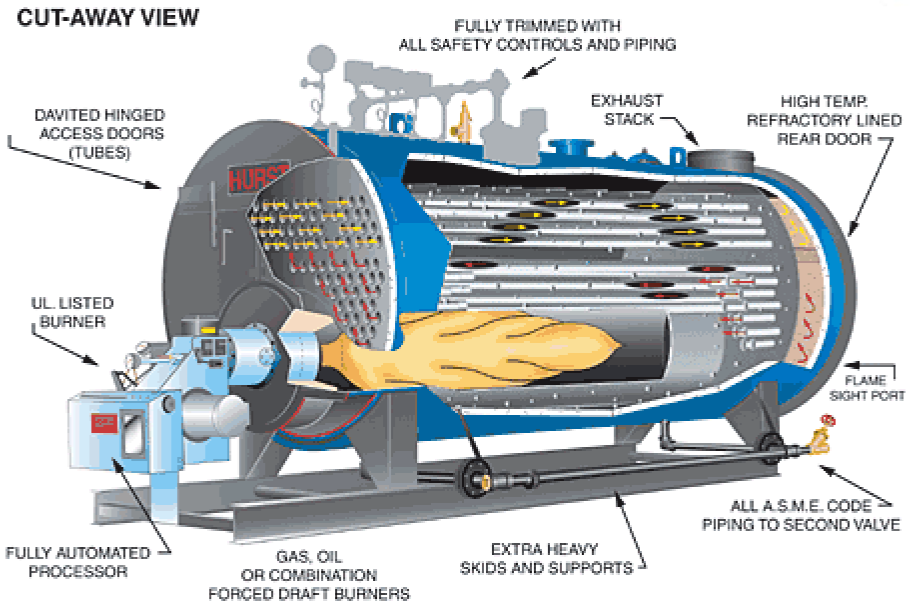



Typical hot water piping system

# Types of Commercial Systems

## Boilers (Steam)


Oil & Gas Fired
Steam Boiler

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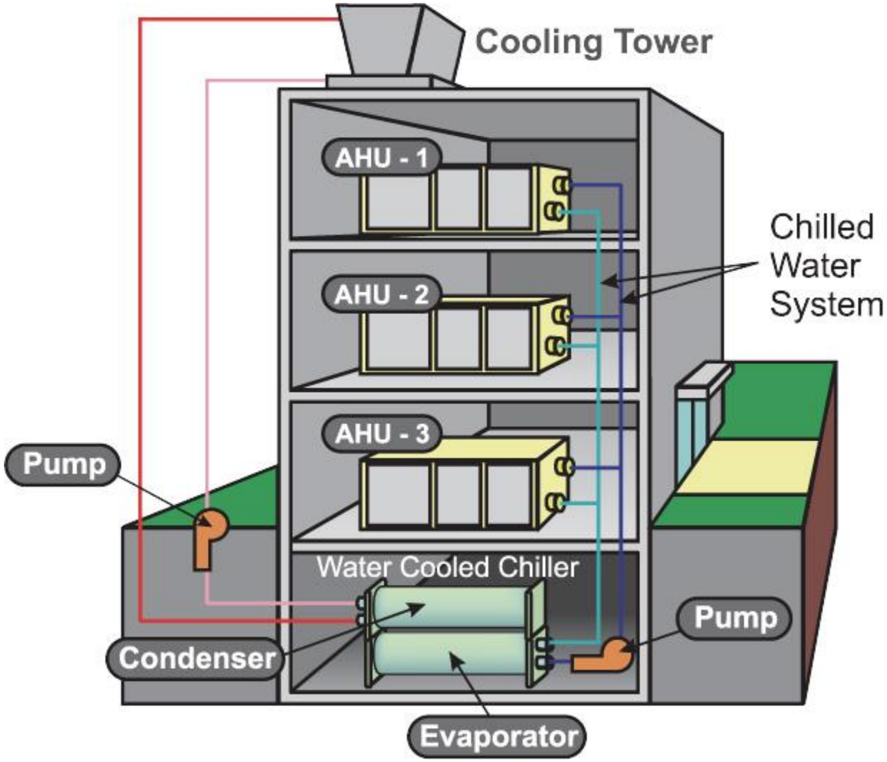
# Types of Commercial Systems

## **Chillers -** Typically Air & Water Cooled

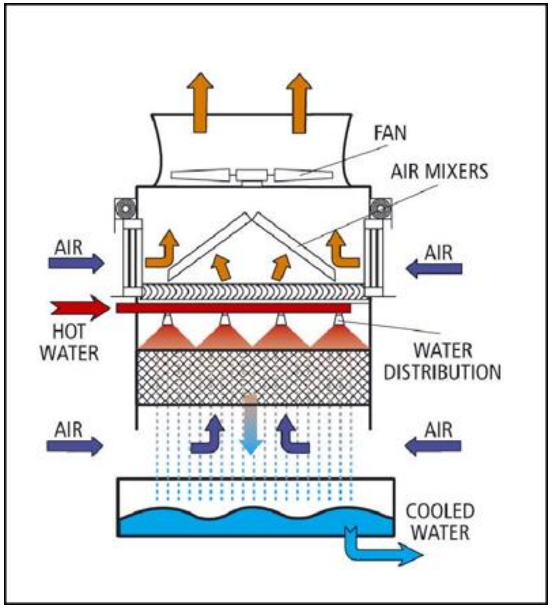


# Types Of Commercial Systems

**Chiller (Air Cooled)** Air-cooled chillers are similar to water-cooled chillers. Both are refrigeration systems that are common in mechanical industries. They both use the same basic principles to generate cooling power, but they use different substances to cool the condensers. Air-cooled chillers do this with the use of air.

# Types of Commercial Systems

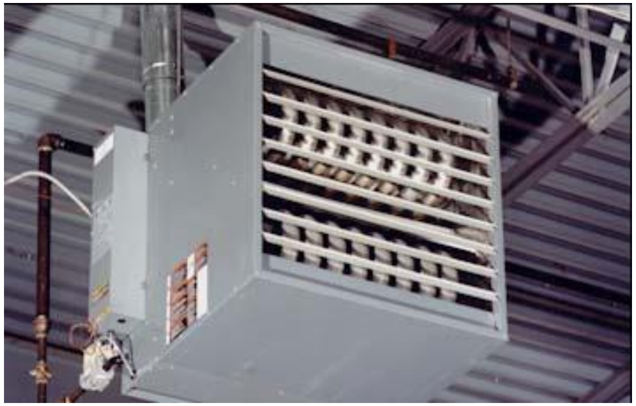
**Cooling Towers:** *From Wikipedia*: Is a heat rejection device which extracts waste heat to the atmosphere through the cooling of a water stream to a lower temperature.



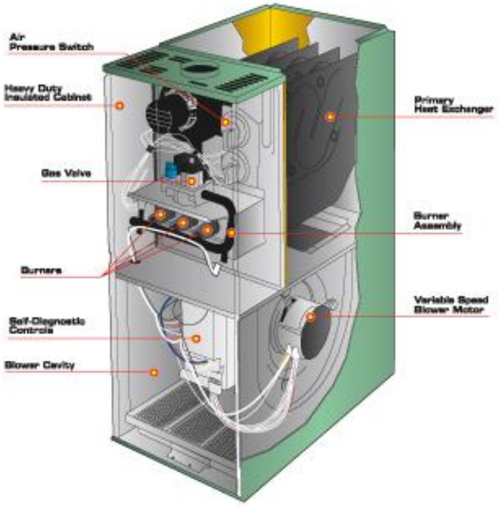

# Types of Commercial Systems

**Heaters**

- Gas Fired Unit Heater
- Forced Air Furnace
- Infra-Red Heater



FURNACE GAS-HOT AIR





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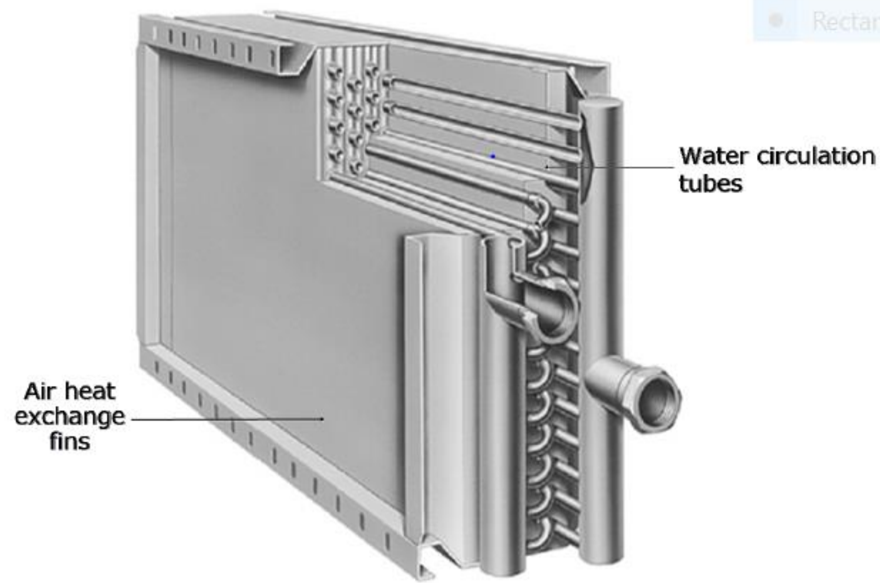
# Types of Commercial Systems

**Fans and Ventilation:** The use of fans to ventilate a space for cooling and/or expulsion of indoor pollutants can be done in many ways. From a simple toilet exhaust fan to huge wall fans interconnected with wall louvers used for summer cooling, there are many ways to ventilate.

# Types of Commercial Systems

**Heating and cooling coils or elements** are normally included in a centralized AHU to provide temperature control for the distributed supply air.  Larger AHUs utilize heat exchanger coils that can circulate hot water or steam from a central boiler for heating, and chilled water from a central chiller system for cooling.

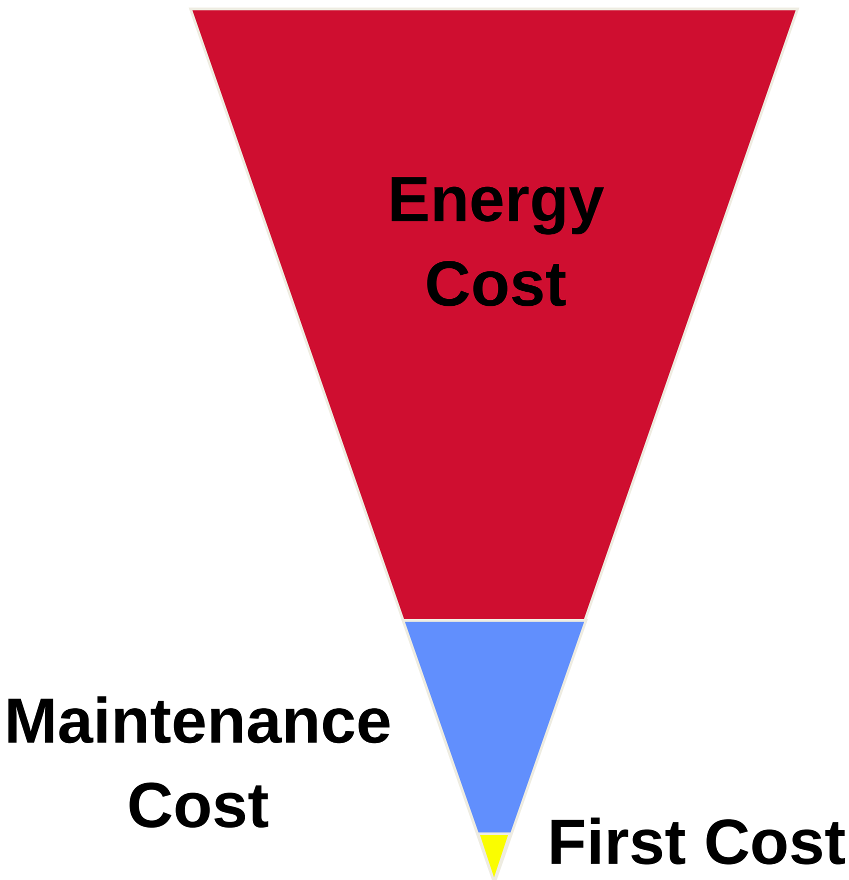
Cooling or Heating Coil



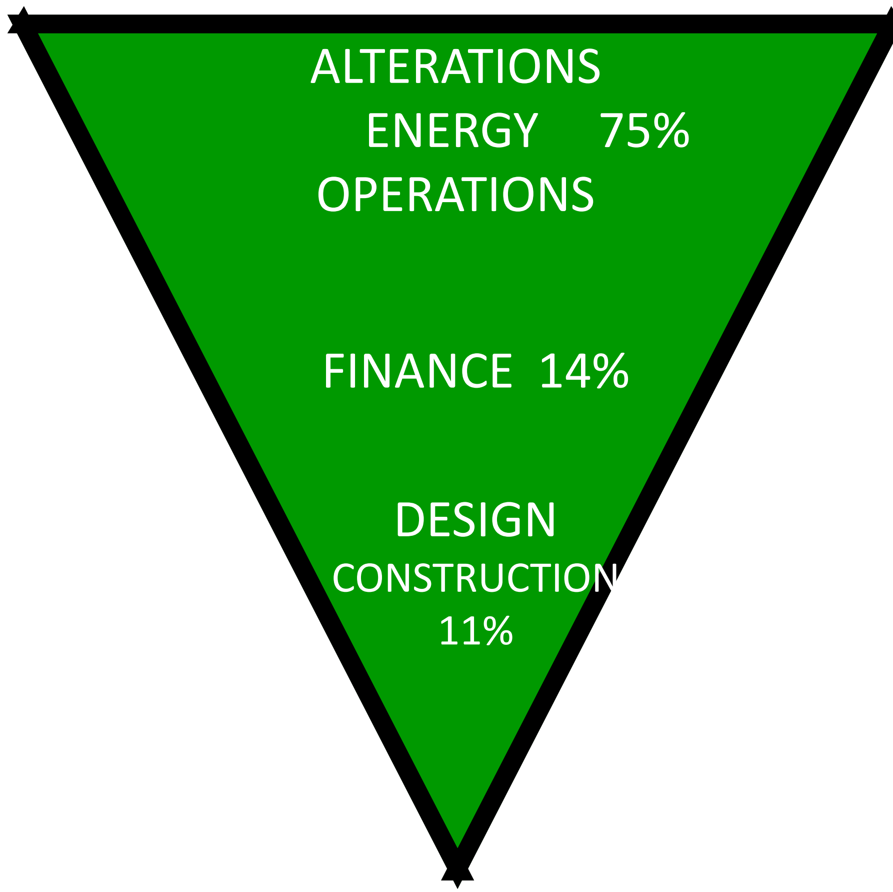
# Air Filters

With Today's ever-increasing emphasis on indoor air quality, filtering has become an important factor in design and operation of the air distribution system.

# Energy Systems Total Cost of Ownership




Life Cycle Cost of a Building



# Benefits Of Planned Maintenance

## Energy Savings

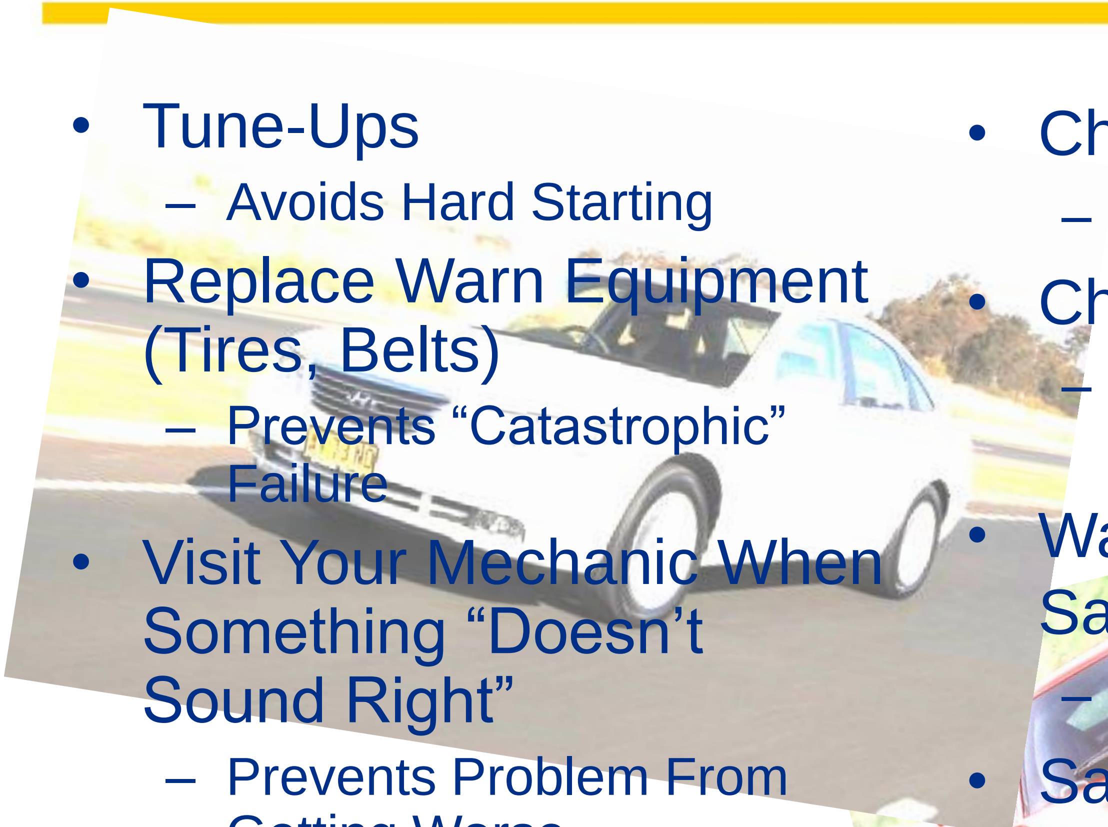
The beginning of energy savings starts with proper maintenance.

Industry experience demonstrates the following savings from planned maintenance activities:

| | |
|---|---|
| **5% - 15%** | **Cleaning Coils** |
| **8% - 10%** | **Re-Alignment of Belts** |
| **10% - 15%** | **Replacing Dirty Filters** |
| **12% - 15%** | **Proper burner efficiency** |
| **7% - 9%** | **Removing Soot from Burners** |
| **20% - 25%** | **Operating Sequence Adjustments** |

Source: DEPARTMENT of ENERGY

# Regular Car Maintenance



- Tune-Ups
  - Avoids Hard Starting
- Replace Warn Equipment (Tires, Belts)
  - Prevents "Catastrophic" Failure
- Visit Your Mechanic When Something "Doesn't Sound Right"
  - Prevents Problem From Getting Worse
  - Prevents You From Being Stranded
- Check & Change the Oil
  - Protects The Engine
- Check The Tire Pressure
  - Improves Performance & Mileage
- Wash To Remove Road Salt
  - Prevents Rust
- Safety & Emissions Inspection
  - Keeps Your Car "Legal"

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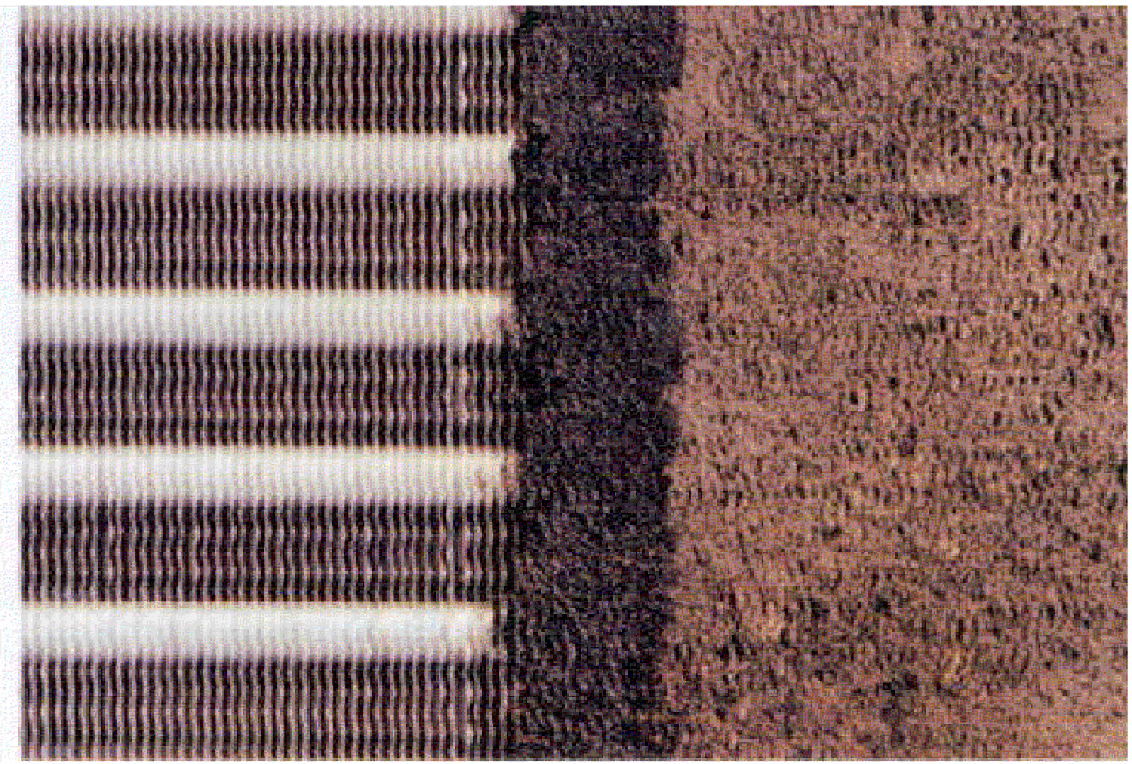
# What is the cost of Preventative Maintenance?

- **Fact:** **Fuel costs continue to rise.**
- **Fact:** **Energy consumption is greatly increased with dirty coils and dirty filters.**
- **Fact:** **Proper preventative maintenance can provide energy savings more than the maintenance cost itself.**
- **Fact:** **Energy costs will only increase.**
- **Fact:** **The most basic maintenance procedures provide the best cost savings.**

# How Clean are your Coils and Filters?



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# Condenser Coils

- **Dirty condenser coils can cost as much as 1/3 more to operate than well maintained coils.**

- **Dirty coils provide inadequate heat transfer, causing higher discharge pressures, leading to increased electricity use and reduced capacity of the unit.**

- **Elevated pressure and temperature can lead to compressor lubricant breakdown, acid formation and ultimate equipment failure.**

# Condenser Coils

## Progressive Effects of Scale On Air Cooled Condenser

| Thickness of Scale in Inches | | % Loss of Heat Transfer |
|---|---|---|
| .000 | | 0 |
| .006 | Human Hair | 16% |
| .012 | Index Card | 20% |
| .024 | | 27% |
| .036 | Paper Clip | 33% |

## Particle Settling Rate

Distance 8 Feet

10 Microns – 6.8 Minutes
1 Micron – 58 Minutes
0.1 Micron – 37.7 Hours

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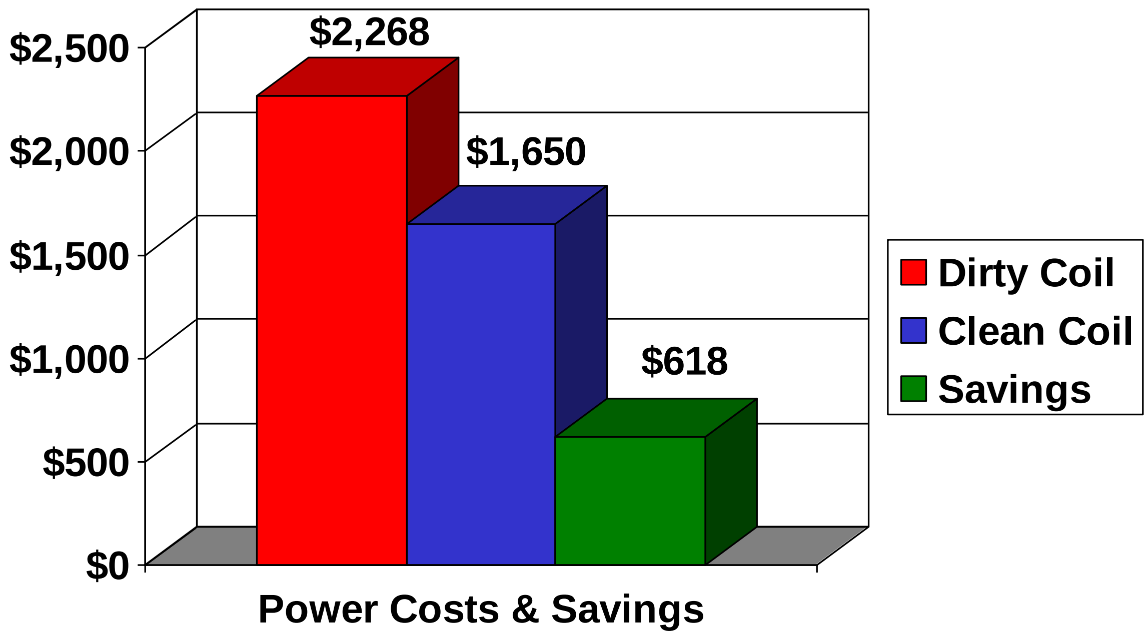
# Condenser Coils

**A typical 10-ton air conditioning system operating for an average cooling season of 1,500 hours**




If you multiply your total building tonnage by $62, you can see the savings

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# V-Belts

- **Proper tensioning of V-belts is the single most important factor necessary for long, efficient and acceptable belt operation.**

- **Too little tension results in slippage, causing rapid belt and sheave wear, and loss of productivity.**

- **Too much tension puts excessive stress on belts, bearings and shafts, reducing energy.**

# Energy Consumption

- Your HVAC equipment is responsible for 40% of your school's energy costs.
- **80% of that energy consumption is due to the system overcoming static pressure across the filter bank.**
- Filters that provide good efficiency with low pressure drop are ideal.
- Well managed filter changes save energy.

# ASHRAE Handbook Life Cycle Costs

| Equipment Type | Years | Equipment Type | Years |
|---|---|---|---|
| **Air Conditioning Units** | | **Coils** | |
| Window Units | 10 | DX, Water, or Steam | 20 |
| Residential Units | 15 | Electric | 15 |
| Commercial Through the Wall | 15 | **Heat Exchangers** | |
| Computer Room Units | 15 | Shell-and-Tube | 24 |
| Water-Cooled Package | 15 | **Reciprocating Compressors** | 20 |
| **Heat Pumps** | | **Package Chillers** | |
| Residential Air-to-Air | 10 | Reciprocating | 20 |
| Commercial Air-to-Air | 15 | Centrifugal | 23 |
| Commercial Water-to-Air | 19 | Absorption | 23 |
| **Rooftop Air Conditioners** | | **Cooling Towers** | |
| Single-zone | 15 | Galvanized Metal | 20 |
| Multizone | 15 | Wood | 20 |
| **Boilers, Hot Water (Steam)** | | Ceramic | 34 |
| Steel Water-Tube | 24(30) | **Air-Cooled Condensers** | 20 |
| Steel Fire-Tube | 25(25) | **Evaporative Condensers** | 20 |
| Cast Iron | 35(30) | **Insulation** | |
| Electric | 15 | Molded | 20 |
| **Burners** | 21 | Blanket | 24 |
| **Furnaces** | | **Pumps** | |
| Gas or Oil-Fired | 18 | Base-Mounted | 20 |
| **Unit Heaters** | | Pipe-Mounted | 10 |
| Gas or Electric | 13 | Sump and Well | 10 |
| Hot Water or Steam | 20 | Condensate | 15 |
| **Radiant Heaters** | | **Reciprocating Engines** | 20 |
| Electric | 10 | **Steam Turbines** | 30 |
| Hot Water or Steam | 25 | **Electric Motors** | 18 |
| **Air Terminals** | | **Motor Starters** | 17 |
| Diffusers, Grills, and Registers | 27 | **Electric Transformers** | 30 |
| Induction and Fan-coil units | 20 | **Controls** | |
| Air-Washers | 17 | Pneumatic | 20 |
| Duct Work | 30 | Electric, or Electronic | 15 |

# HVAC Components

Component failure rates will depend largely on the owner's proactive approach with planned maintenance versus breakdown repair only. A good planned maintenance program can add 20% or more life to existing equipment. No planned maintenance can deduct 20-30% from typical unit life expectancy.

| HVAC Component Typical Life Expectancy | Typical Failure Rate Expectancy |
|---|---|
| Compressors | Typically 5-15 year range for failures. Most manufacturers warranty 1-5 years only. |
| Condenser Fan Motors | Starts after 3-5 years. |
| Blower Motor | Rarely fail in the first 10 years. |
| Blower Wheels | Rarely fail themselves; are typically replaced due to shaft or bearing failures. |
| Contactors | Typical wear item. Replace every few years. |
| Bearings | Typical wear item. Life span is 1-10 years. |
| Relays | Typical wear item. Replace every few years. |
| Thermostats | Low maintenance item. Failure rate is minimal. More subject to damage by occupant. |
| Timers | Typical life span 5-10 years. |
| Fan Blades | High wear item. Typically replaced with condenser fan motors after 3-5 years. |
| Condensers | Normally last unit life except for severe hail damage. |
| Evaporators | Normally last unit life unless filters are not changed regularly. |
| Heat Exchangers | Failure typically starts at 10 years due to rust and cracks. Note: newer units have thinner metal. |
| Gas Valves | Failures begin at 5-10 year range. |
| Igniters | Typical wear item. Should be replaced every few years. |
| Gas Regulators | Failures begin at 5-10 year range. |
| Actuators | Failures begin at 5-10 year range. |
| Circuit Boards | No-maintenance item. Failures are normally due to other component failures. |

# Health & Safety Awareness

## Safety Training:

Practice it because of things like this…


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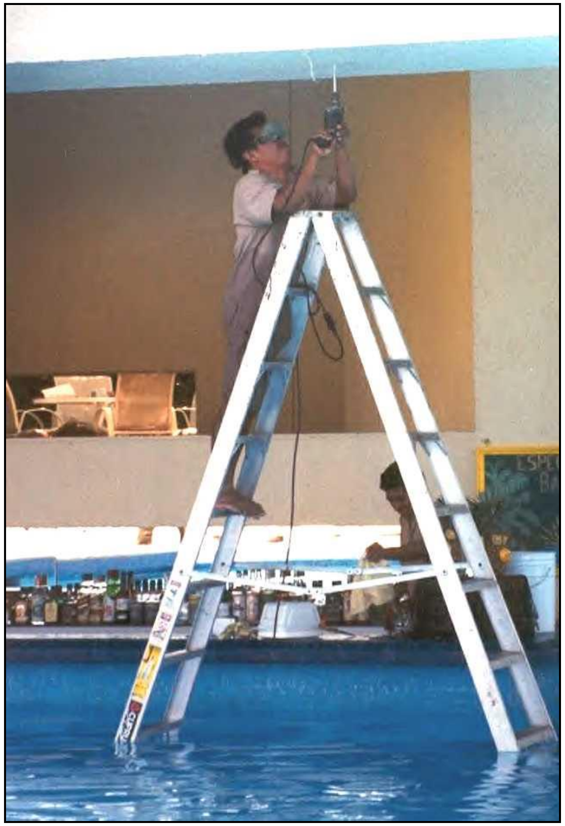
# Safety Training (Cont.)

And this…



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# Safety Training (cont.)

Yes, and this…

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# Equipment Location – Safe Building Access

**"I am going to be working in the following areas- my PPE includes Safety Glasses, ear protection, gloves, and work boots"**

- "Do I require any other items or is there clothing such as badge lanyard or jewelry that should not be worn?"
- "What procedures should I follow related to security, signing in and who to contact?"
- "Are any aspects of Health & Safety covered at that time?"


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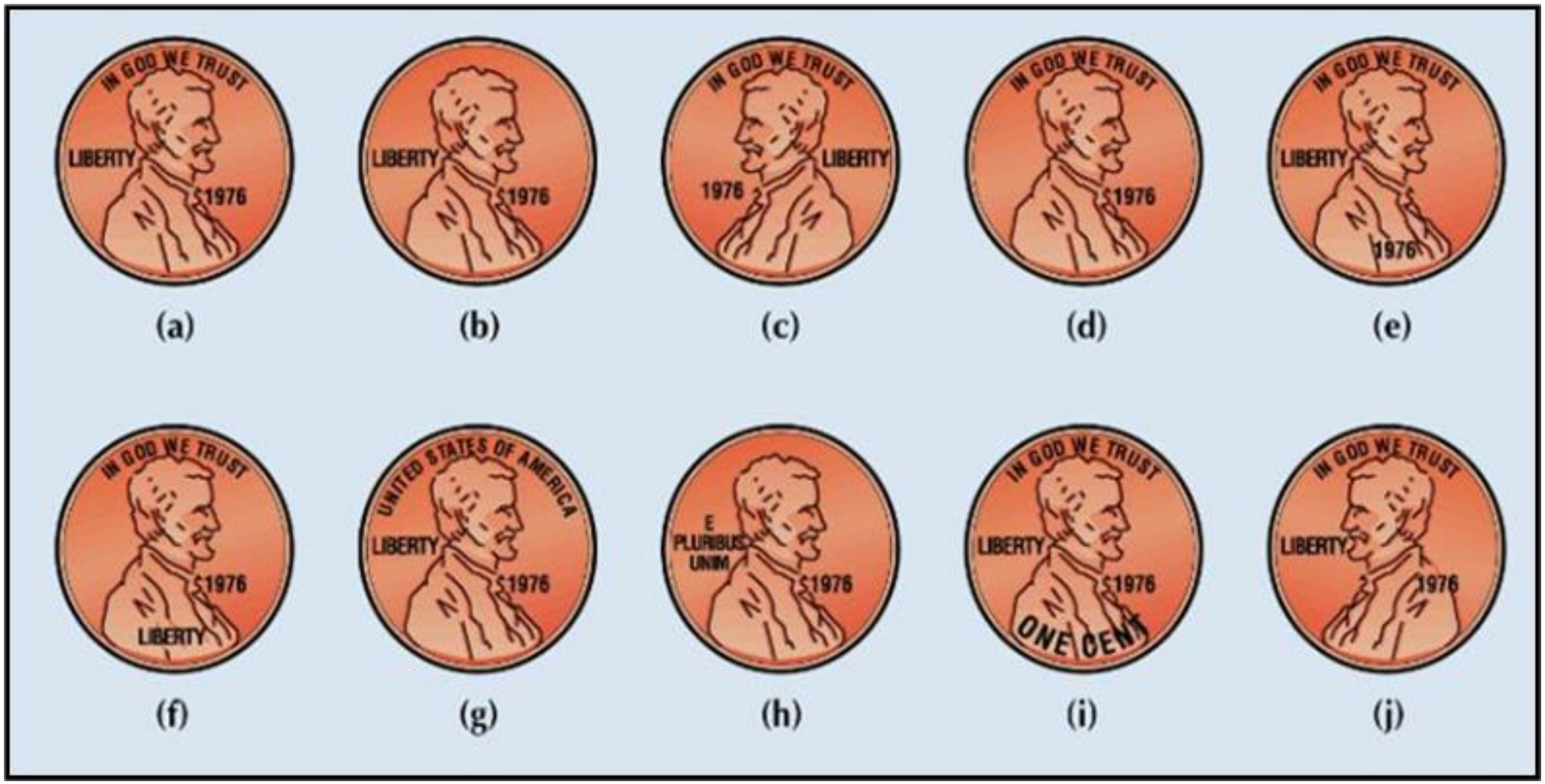
# Home Safely…*Hazard Identification*

## Rooftop Work

- Access Using Ladders, fixed, extension, how tall
- Hatches and Openings, Distance from roof edge
- Equipment Location (Roof or Mechanical Room)
- Surrounding Environment, noise, weather,
- Opening Units?  De-energizing electrical

# Inspecting Equipment Accurately is Very Important

## Know what you're looking at!



# Working On Equipment – The Safety Factor

- Identifying equipment that may be difficult to access
- What obstacles could be out there?
  - Landscaping
  - Snow, ice
  - Animals (ex: Snakes, Bees, Wasps, Insects etc.)
  - Skylights
  - Garbage or other debris
  - Height of first step
  - Properly secured to the building

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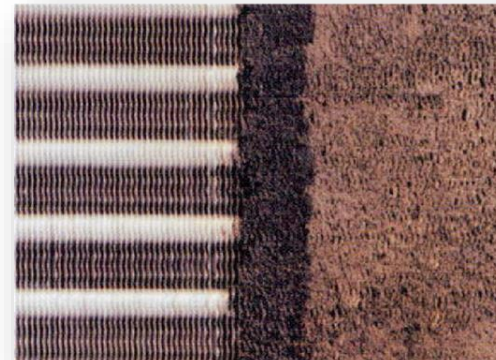
# HVAC Equipment – The Safety Factor

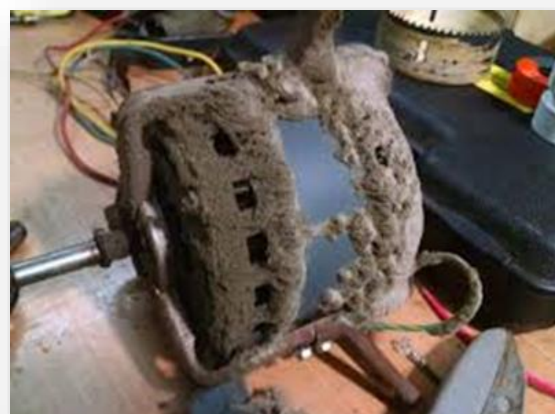
*Safety issues: What to look for and why*

- Roof access conditions
- Hard to get to access
- Poor lighting
- Skylights
- Overhead Obstacles
- Trip Hazards
- Walkways
- Wet slippery floors
- Hazardous Areas (chemicals present)
- Over Head Work (workers working above you)

# Equipment Neglect – What to look for and what to do with it

- Dirty air filters
- Faulty drive belts
- Dirty motors
- Burnt contact points
- Refrigerant leaks
- Plugged drains
- Trash on roof
- Missing/loose panels





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# Performance Impacts

ASHRAE Journal

| Changes in rooftop operation due to refrigerant leakage | | | | |
|---|---|---|---|---|
| (% leakage) | % Change in Capacity | % Change in COP | Change in $T_{sh}$ ( F) | Change in $T_{hg}$ ( F) |
| 3.5 | 3.0 | 2.7 | 3.5 | 3.3 |
| 7.0 | 3.8 | 2.8 | 7.0 | 6.1 |
| 10.5 | 5.6 | 3.6 | 9.9 | 8.4 |
| 14.0 | 8.0 | 4.6 | 11.1 | 10.0 |
| **Changes in rooftop operation due to liquid line restriction** | | | | |
| (% $\Delta$P) | % Change in Capacity | % Change in COP | Change in $T_{sh}$ ( F) | Change in $T_{hg}$ ( F) |
| 5 | 3.5 | 3.0 | 5.5 | 5.8 |
| 10.0 | 5.2 | 3.7 | 8.7 | 8.8 |
| 15.0 | 8.8 | 5.1 | 11.9 | 12.2 |
| 20.0 | 17.2 | 8.7 | 16.0 | 16.6 |
| **Changes in rooftop operation due to compressor valve leakage** | | | | |
| Fault Level (% $\Delta \eta_v$) | % Change in Capacity | % Change in COP | Change in $T_{sh}$ ( F) | Change in $T_{hg}$ ( F) |
| 7 | 7.3 | 7.9 | -3.6 | 0.2 |
| 14 | 9.6 | 10.5 | -4.8 | 0.0 |
| 28 | 12.5 | 14.0 | -7.2 | 0.1 |
| 35 | 21.3 | 23.8 | -11.8 | 0.6 |
| **Changes in rooftop operation due to condenser fouling** | | | | |
| (% area block) | % Change in Capacity | % Change in COP | Change in $T_{sh}$ ( F) | Change in $T_{hg}$ ( F) |
| 14 | 3.1 | 4.3 | 0.8 | 2.2 |
| 28 | 4.8 | 7.7 | 4.2 | 2.6 |
| 42 | 7.4 | 12.2 | 8.0 | 3.1 |
| 56 | 10.9 | 17.9 | 11.2 | 4.5 |
| **Changes in rooftop operation due to evaporator fouling** | | | | |
| (% $\Delta$ airflow) | % Change in Capacity | % Change in COP | Change in $T_{sh}$ ( F) | Change in $T_{hg}$ ( F) |
| 12 | 6.7 | 6.0 | 2.1 | 1.5 |
| 24 | 13.6 | 12.3 | 3.9 | 3.2 |
| 36 | 19.4 | 17.4 | 5.5 | 5.1 |

Table 4: Effect of degradation faults on a 3-ton (10.6 kW) rooftop unit with a fixed-orifice expansion device.

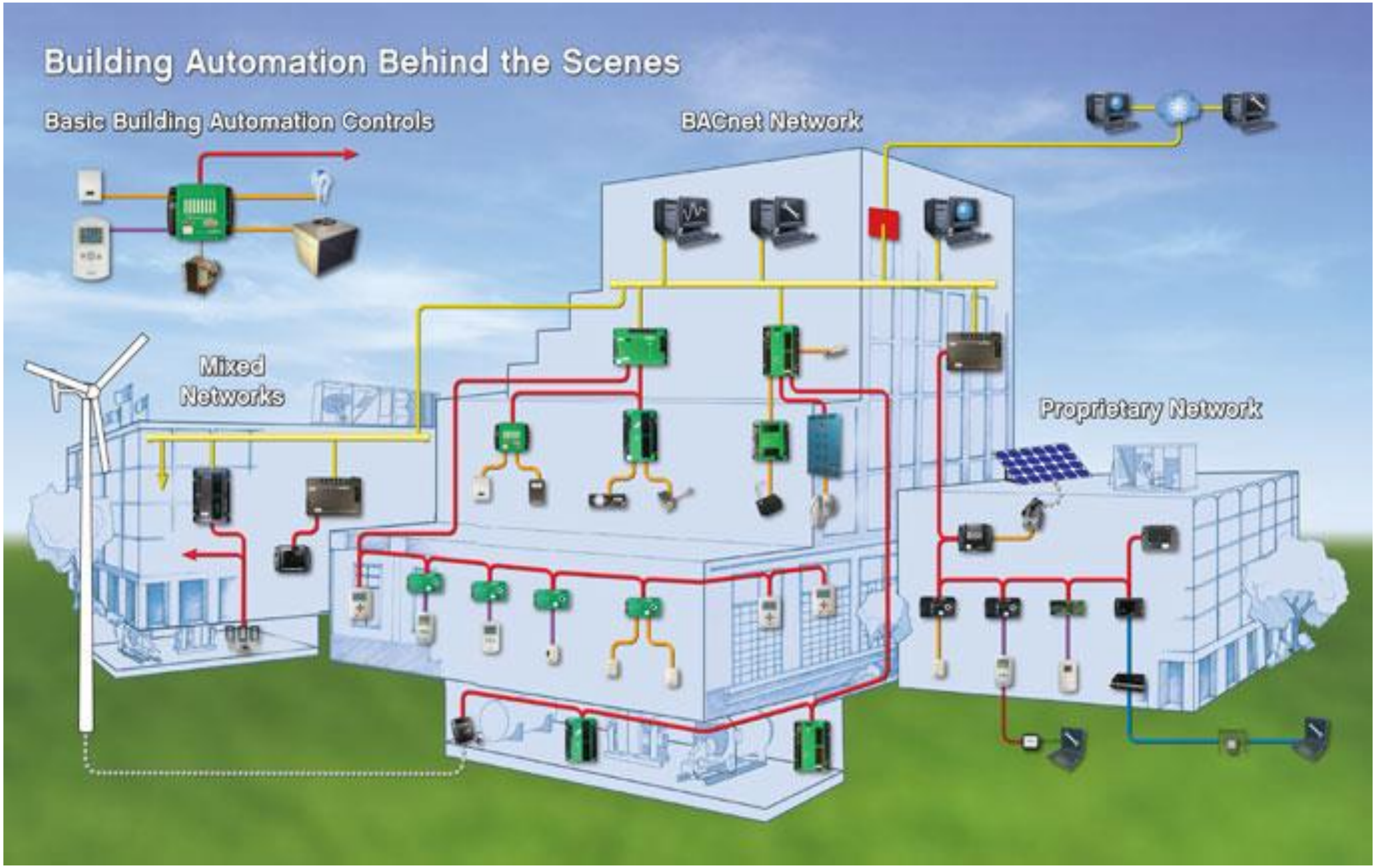
# What is a Building Automation System (BAS)?
# Direct Digital Control (DDC)?

Building Automation System is the centralized control of a buildings heating, ventilation and air conditioning, lighting and other systems through a dedicated system.

Equipment needs a control system to regulate its operation to meet changing needs of indoor spaces.

A method of monitoring and controlling building systems performance by collecting, processing, and sending information using sensors, actuators, and microprocessors.

# Building Automation

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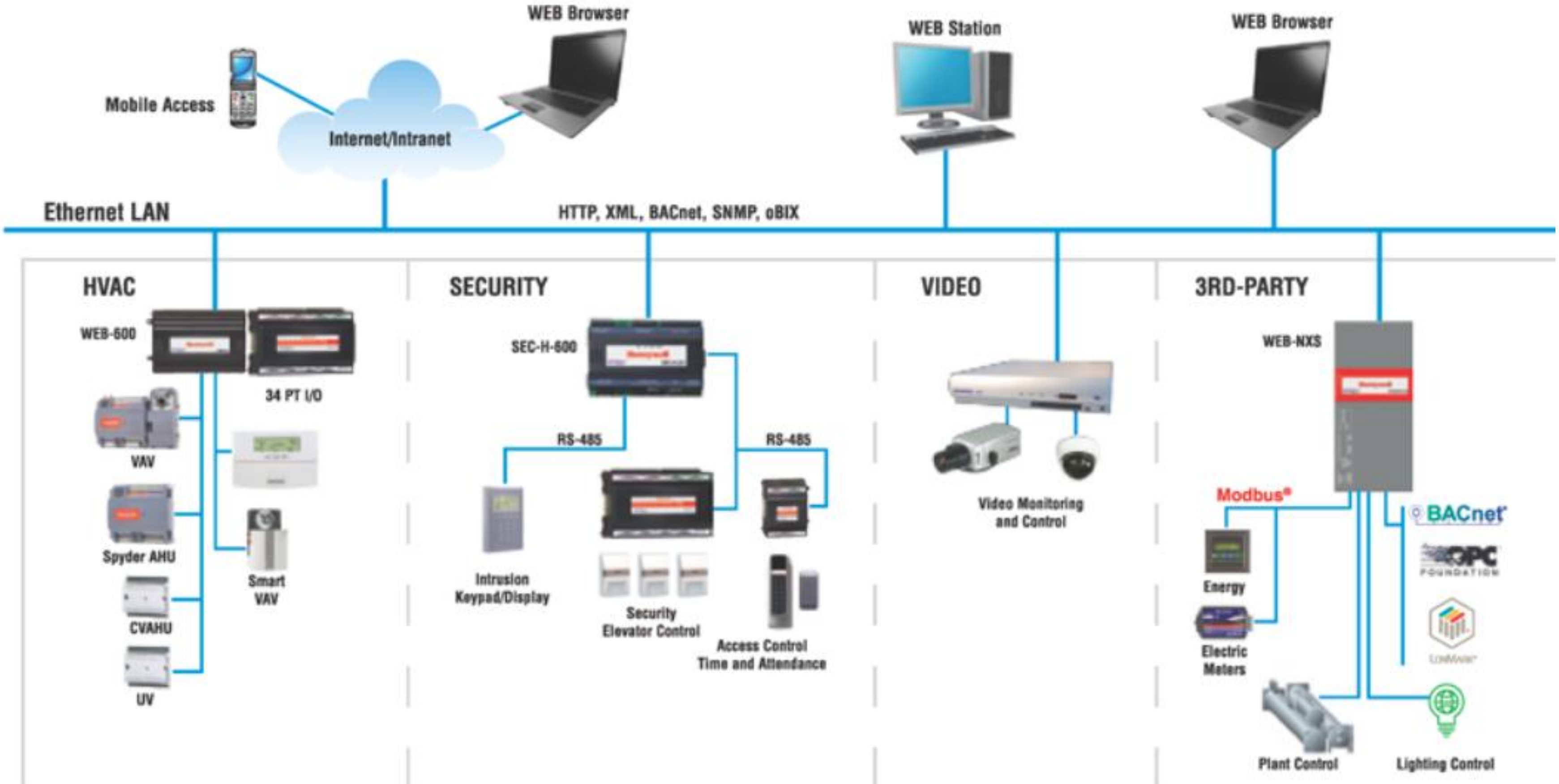
# Building Automation Overview

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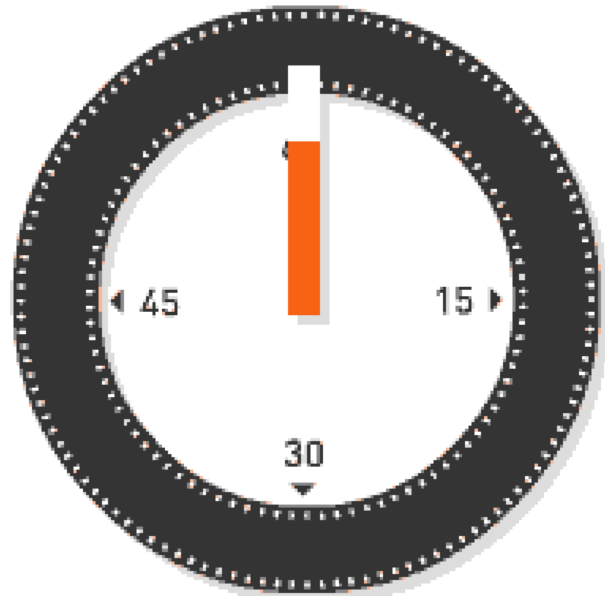
# Time for Questions?

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# Thank you for meeting us today!

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