What to consider for updating your HVAC system

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nexus SOLUTIONS®

Illingworth-Kilgust Mechanical
An EMCOR Company

Introductions

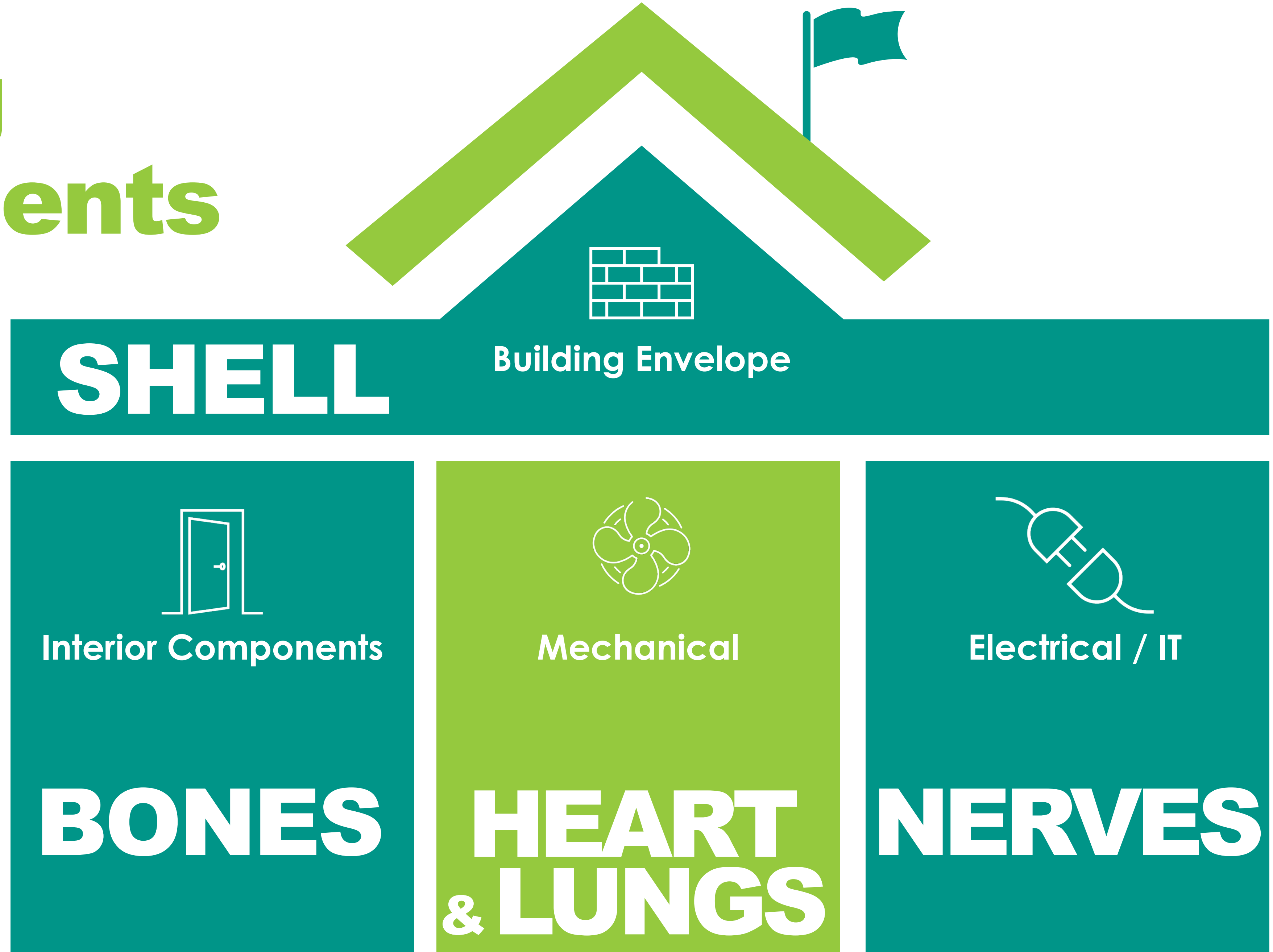
Russ Schumacher
Co-Founder and
Director of Design and
Commissioning
Nexus Solutions

David Bavisotto
Vice President, Sales and
Business Development
Illingworth-Kilgust Mechanical

Today's agenda

- ✓ Why update
- ✓ When to update
- ✓ Where to start
- ✓ What type of system
- ✓ Who is on your team

Building components



Glossary of today's terms

term	definition
ASHRAE	American Society of Heating and Refrigeration and Air Conditioning Engineers *Basis for Building Codes and Mechanical System Design*
HVAC	Heating Ventilating and Air Conditioning *Acronym for a building's mechanical equipment*
IAQ	Indoor Air Quality *Refers to the air quality within and around building structures, especially as it relates to the health and comfort of building occupants*
AIR HANDLING UNIT	Mechanical Unit which has dampers, filters, heating and cooling coils, and a fan to circulate air throughout the building.
Ventilation	The intentional introduction of fresh outdoor air into occupied spaces.
Filter	Porous material component within the air handling unit which filters the building impurities from the circulated air.

Why update

Improved Equipment Operation

Reduced Maintenance

Improved Efficiency

Improved Indoor Air Quality and Filtration

Why are you updating?

Comfortable Learning Environment

Main purpose of HVAC systems is to provide occupants with "conditioned" air

Comfortable and safe work (learning) environment

Air Conditioning

"Conditioned" air means that air is clean and odor-free, and the temperature, humidity, and movement of the air are within certain comfort ranges

Improved Ventilation

“Ventilation” air is the amount of code required outdoor fresh air required by the space (Varies with space type)

Reduced Maintenance

How is your maintenance documented?

Budget Watch

Red	At or beyond useful life
Orange	less than 3 years from end of useful life
Yellow	less than 5 years from end of useful life
Green	Over 5 years away from end of useful life

WI School District

Unit ID	Asset Description	Vintage	Life Expectancy per ASHR	Life Expectanc	Anticipated Life Expectancy Based on Current	Existing Defici	Location	Manufacturer	Tonnage/MBH	Model Number	Serial Number	Refrigerant Type
BL-01	Boiler	2007	25	10			North Bldg	Fulton	500 MBH	PHW-500	103725	
BL-02	Boiler	2007	25	10			North Bldg	Fulton	501 MBH	PHW-500	103724	
BL-03	Boiler	2007	25	10			North Bldg	Fulton	502 MBH	PHW-500	108393	
BL-04	Boiler	2011	25	14			South Bldg	Lochinvar	503 MBH	KEN501	K11H10203592	
BL-05	Boiler	2016	25	19			North bldg	M3 Riverside Hydronics	504 MBH	500WB 130A-CBMI	F000332	
BL-06	Boiler	2018	25	21			South Bldg	Cleaver Brooks	700hp	CFH-700-10-15ST	014614-2-1	
BL-07	Boiler	2015	25	18			south bldg	HTP	114 MBH	UFT-120W	060915SA500096	
BL-08	Boiler	2015	25	18			south bldg	HTP	115 MBH	UFT-120W	060915SA500074	
BL-09	Boiler	2018	25	21			south bldg	HTP	116 MBH	UFT-199W	032818SA900275	
BL-10	Boiler	2018	25	21			south bldg	HTP	117 MBH	UFT-199W	032818SA900257	
BL-11	Boiler	2017	25	20			south bldg	HTP	118 MBH	UFT-199W	011917SA900051	
Cabinet cooler	Pkgd (HP)- AC (All)	2016	25	19				Thermal Edge	119 MBH	HC10148612	1616040001	
CH-1	Chiller	2014	23	15			Mechanical Room	AEC	113 tons	03RC-420	44C1049	R134A
CH-2	Chiller	2012	23	13			Mechanical Room	AEC	195 tons	RSR-195	42H0430	R134A
CH-3	Chiller	2014	23	15			Mechanical Room	AEC	113 tons	GSRC-420	44C1049	R134A
CH-4	Chiller	2012	23	13			Mechanical Room	AEC	195 tons	RSR-195	42H0430	R134A
CH-5	Chiller New South Addition	2022	23	23			Mechanical Room	Daikin		AW018BJJNKKNOB	STNU211200095	R134A
Cooler - South Break	Cooler (commercial refrigeration)	x	x	#VALUE!				True	#N/A	T-49	748359	
CU-1	Condensing Unit		20	#VALUE!			Roof	AAON				
CU-10	Condensing Unit	2014	20	12			Ground Level East Side	Heatcraft		LNHD08A058	T14E16390	
CU-11	Condensing Unit	2019	20	17			Roof	Heatcraft		BDT1200M6D	T19L05240	
CU-1MUA-2	Split DX- CU	2012	20	10				Carrier		38AUDA16AOA6AOAOAO	3012U33465	
CU-2	Condensing Unit	2017	20	15			Roof	AAON		CFA-050-D-A-3-GC00L	201710-CNCV03564	R410A
CU-3	Condensing Unit	2012	20	10			Ground Level North Side	Heatcraft		LNHD08A058	T12H18613	
CU-4	Condensing Unit	2014	20	12			Ground Level North Side	AEC	113 tons	RC-420	44E0615	R134A
CU-5	Condensing Unit	2014	20	12			Ground Level North Side	AEC	113 tons	RC-420	44E0616	R134A
CU-6	Condensing Unit	2012	20	10			Ground Level North Side	Heatcraft		LNHD08A058	T12H18614	
CU-7	Condensing Unit	2014	20	12			Ground Level East Side	Heatcraft		LNHD08A058	T14E10494	

Reduced Maintenance

Are maintenance costs increasing?

Asset Cost

Company Name: School Wisconsin USA

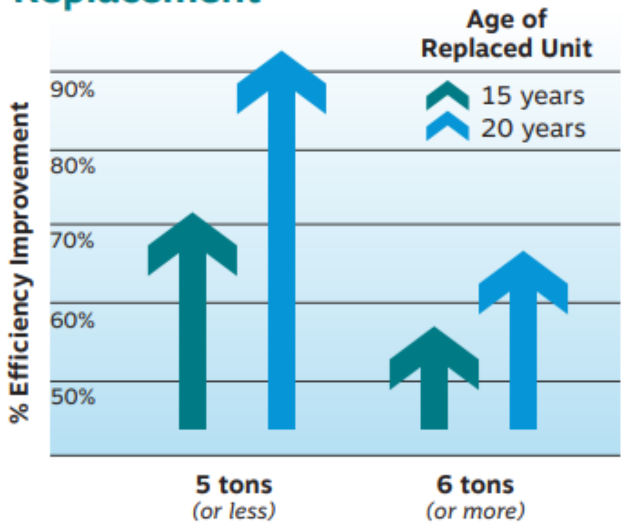
Unit ID	2020	Description 2020	PM 2020	2021	Description 2021	PM 2021	2022	Description 2022	PM 2022	Repairs
Bar Line	$25,062.20	Install Refrigerant Lines		$443.10			$1,618.00			$27,123.30
BL-01	$1,555.26		$727.09	$2,278.45		$781.09	$30.84	Parts	$820.18	$3,864.55
BL-02	$2,154.50		$727.09	$419.80		$781.09	$30.84	Parts	$820.18	$2,605.14
BL-03	$222.45		$727.09			$781.09	$30.84	Parts	$820.18	$253.29
BL-04	$1,536.40		$727.09	$1,614.60		$781.09	$30.84	Parts	$820.18	$3,181.84
BL-05	$2,709.92		$727.09			$781.09	$30.84	Parts	$820.18	$2,740.76
BL-06	$6,180.69		$727.09			$781.09	$30.84	Parts	$820.18	$6,211.53
BL-07	$222.45		$727.09			$781.09	$30.84	Parts	$820.18	$253.29
BL-08	$222.45		$727.09			$781.09	$30.84	Parts	$820.18	$253.29
BL-09	$222.45		$727.09			$781.09	$30.84	Parts	$820.18	$253.29
BL-10	$222.45		$727.09	$1,248.97		$781.09	$30.84	Parts	$820.18	$1,502.26
BL-11	$222.45		$727.09			$781.09	$30.84	Parts	$820.18	$253.29
Cabinet cooler	$1,281.83									$1,281.83
CH-1			$1,533.00	$17,031.54		$1,658.00	$7,209.17		$2,291.50	$24,240.71
CH-2	$3,063.72		$1,533.00	$787.56		$1,658.00	$419.75		$2,291.50	$4,271.03
CH-3			$1,533.00	$7,660.60		$1,658.00			$2,291.50	$7,660.60
CH-4			$1,533.00	$2,811.56		$1,658.00	$94,312.25		$2,291.50	$97,123.81
CH-5 New South Addition 2022										$0.00
Cooler - South Break	$2,455.26									$2,455.26
Cooling Tower										$0.00

Improved Efficiency

Department of Energy's new minimum efficiency standards, for commercial packaged air conditioners and heat pumps, will go into effect on **January 1, 2023.**

The new minimum will result in an average increase in energy efficiency of 15% from the 2018 standards.

Expected Efficiency Improvement with Replacement



Assess Your Equipment

Develop a plan to assess and replace any existing equipment that is past its published useful life

Proactive Strategy

Equipment plans specific to your needs:

- ✓ Proper maintenance of equipment, repairs as needed
- ✓ Identify a qualifying basis for replacements based on age/ condition
- ✓ Prioritize replacements, considering factors such as critical needs, industry conditions

Planned Replacements

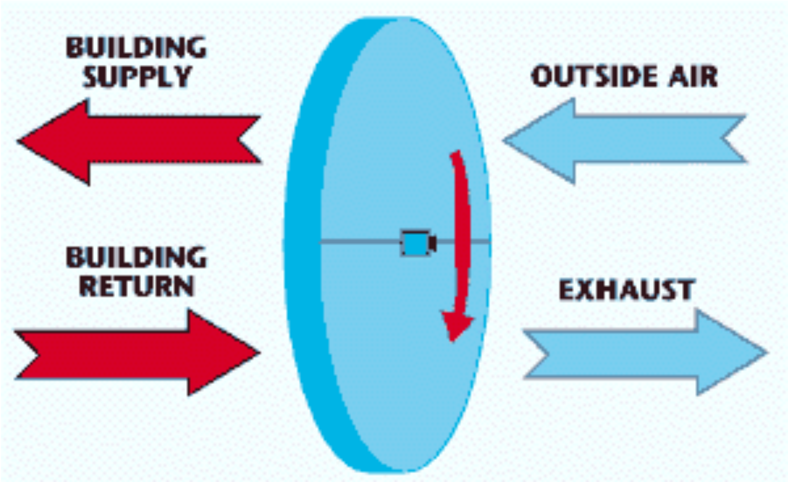
Replace qualifying equipment as soon as funding allows:

- ✓ Equipment costs have risen 40% since 2021 and continue to rise
- ✓ Lead times are long due to supply chain issues
- ✓ In 2025 new HVAC equipment will require A2L refrigerants, which are "slightly flammable" further increasing costs

Improved Efficiency

High Efficiency Boilers

High Efficiency Water Heaters



Condensing Unit

Chiller

Energy Recovery

Ventilation code requirements
"The Solution to Pollution is Dilution"

TABLE 6-1 MINIMUM VENTILATION RATES IN BREATHING ZONE
(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)

Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Notes	Default Values: Occupant Density (see Note 4)	Default Values: Combined Outdoor Air Rate (see Note 5)		Air Class
	cfm/person	L/s·person	cfm/ft^2	L/s·m^2		#/1000 ft^2 or #/100 m^2	cfm/person	L/s·person	
Correctional Facilities									
Cell	5	2.5	0.12	0.6		25	10	4.9	2
Dayroom	5	2.5	0.06	0.3		30	7	3.5	1
Guard stations	5	2.5	0.06	0.3		15	9	4.5	1
Booking/waiting	7.5	3.8	0.06	0.3		50	9	4.4	2
Educational Facilities									
Daycare (through age 4)	10	5	0.18	0.9		25	17	8.6	2
Daycare sickroom	10	5	0.18	0.9		25	17	8.6	3
Classrooms (ages 5–8)	10	5	0.12	0.6		25	15	7.4	1
Classrooms (age 9 plus)	10	5	0.12	0.6		35	13	6.7	1
Lecture classroom	7.5	3.8	0.06	0.3		65	8	4.3	1
Lecture hall (fixed seats)	7.5	3.8	0.06	0.3		150	8	4.0	1
Art classroom	10	5	0.18	0.9		20	19	9.5	2
Science laboratories	10	5	0.18	0.9		25	17	8.6	2
University/college laboratories	10	5	0.18	0.9		25	17	8.6	2
Wood/metal shop	10	5	0.18	0.9		20	19	9.5	2
Computer lab	10	5	0.12	0.6		25	15	7.4	1

The importance of filtration

What filtration levels are important to your district?

Improved Indoor Air Quality and Filtration

What filtration levels are important to your district?

ASHRAE STANDARD 52.2 - 2017 **MERV RATING FILTRATION APPLICATION GUIDELINE**

MERV STANDARD 52.5	AVERAGE ARRESTANCE	CONTROLLED CONTAMINANT	TYPICAL APPLICATIONS	TYPICAL AIR FILTER / CLEANER TYPE
16	n/a	**0.30 - 1.00ppm particle size** Talcum Dust	General Surgery	**Bag Filter** - Nonsupported microfine fiberglass or synthetic media. 12" - 36" deep w/ 6 - 12 pockets **Box or Pleated Filters** - Rigid Style Cartridge or Pleated Filters 2" to 12" deep may use lofted or paper media
15	n/a	All Bacteria Smoke	Hospital Inpatient Care	
14	> 98%	Most Tobacco	Smoking Lounges	
13	> 98%	Droplet Nuclei (Sneeze) Bacteria	Superior Commercial Buildings	
12	> 95%	**1.00 - 3.00ppm particle size** Legionella, Welding Fumes	Superior Residential Buildings	**Bag Filter** - Nonsupported microfine fiberglass or synthetic media 12" - 36" deep w/ 6 - 12 pockets **Box Filter** - Rigid Style Cartridge Filters 2" to 12" deep may use lofted or paper media
11	> 95%	Humidifier Dust Lead Dust		
10	> 95%	Auto Emissions		
9	> 90%	Milled Flour	Hospital Laboratories	
8	> 90%	**1.00 - 3.00ppm particle size** Mold Spores	Commercial Buildings	**Pleated Filters** - Disposable, extended surface area, thick with cotton-polyester blend media & cardboard frame **Cartridge Filters** - Graded density viscous coated cube or pocket filters, synthetic media **Throwaway** - Disposable synthetic panel filter
7	> 90%	Hair Spray	Better Residential	
6	85 - 90%	Fabric Protector Dusting Aids	Industrial Workplaces	
5	80 - 85%	Cement Dust Pudding Mix	Paint Booth Inlets	
4	75 - 80%	**0.30 - 1.00ppm particle size** Pollen	Minimal Filtration	**Throwaway** - Disposable synthetic or fiberglass panel filter **Washable** - Aluminum Mesh **Electrostatic** - Self-charging woven panel filter
3	70 - 75%	Dust Mites	Residential	
2	65 - 70%	Sanding Dust Spray Paint Dust		
1	< 65%	Textile / Carpet Fibers Lint	Window AC Units	

The solution to pollution is dilution...**and filtration**

Efficiency

If we replace MERV-8 filters with MERV-11 or MERV-13, what would happen to unit performance? Are adjustments required?

$

ΔP

Eff

MERV 8 Pleated	**MERV 11 Pleated**	**MERV 13 Pleated**
Cost	Approx 20% more	Approx 50 – 75% more
SC 2” 500 FPM = 0.21”WG HC = 0.20”WG	SC = 0.33”WG HC = 0.31”WG	Only HC = 0.35”WG
MERV 8	MERV 11	MERV 13

Why update?

Students in well-maintained facilities score 11% higher on standardized tests

A study of the District of Columbia school system found, after controlling for other variables such as a student's socioeconomic status, that students' standardized achievement scores were lower in schools with poor building conditions. Students in school buildings in poor condition had achievement that was 6% below schools in fair condition and 11% below schools in excellent condition.
(Edwards, 1991)

Similarly, Hines' (1996) study of large, urban high schools in Virginia also found a relationship between building condition and student achievement. Indeed, Hines found that student achievement was as much as 11 percentile points lower in substandard buildings as compared to above-standard buildings.

When to update

Equipment Lifecycle

Code Compliance

Phase out of Refrigerants

Component Obsolescence

Equipment Lifecycle

Industry standard recommended equipment life

ashrae.org

ASHRAE Equipment Life Expectancy chart

ASHRAE is the industry organization that sets the standards and guidelines for most all HVAC-R equipment. For additional info about ASHRAE the website is www.ashrae.org .

Equipment Item	Median Years
Air conditioners	
Window unit	10
Residential single or Split	
Package	15
Commercial through-the wall	15
Water-cooled package	15
Heat Pumps	
Residential air-to-air	15
Commercial air-to-air	15
Commercial water-to-air	19
Roof-top air conditioners	
Single-zone	15
Multi-zone	15
Boilers, hot water (steam)	
Steel water-tube	24 (30)
Steel fire-tube	25 (25)
Cast iron	35 (30)
Electric	15
Burners	21
Furnaces	
Gas- or oil-fired	18
Unit heaters	
Gas or electric	13
Hot water or steam	20
Radiant Heaters	
Electric	10
Hot water or steam	25

Equipment Item	Median Years
Air terminals	
Diffusers, grilles, and registers	27
Induction and fan coil units	20
VAV and double-duct boxes	20
Air washers	17
Ductwork	30
Dampers	20
Fans	
Centrifugal	25
Axial	20
Propeller	15
Ventilating roof-mounted	20
Coils	
DX, water, or steam	20
Electric	15
Heat Exchangers	
Shell-and-tube	24
Reciprocating compressors	20
Packaged chillers	
Reciprocating	20
Centrifugal	23
Absorption	23
Cooling towers	
Galvanized metal	20
Wood	20
Ceramic	34

Equipment Item	Median Years
Air-cooled condensers	20
Evaporative condensers	20
Insulation	
Molded	20
Blanket	24
Pumps	
Base-mounted	20
Pipe-mounted	10
Sump and well	10
Condensate 15	
Reciprocating engines	20
Steam turbines	30
Electric motors	18
Motor starters	17
Electric transformers	30
Controls	
Pneumatic	20
Electric	16
Electronic	15
Valve actuators	
Hydraulic	15
Pneumatic	20
Self-contained	10

Preventative Maintenance

Equipment Lifecycle

HVAC component lifecycle

Component failure rates will depend largely on the owner’s **proactive approach with planned maintenance versus breakdown repair only.**

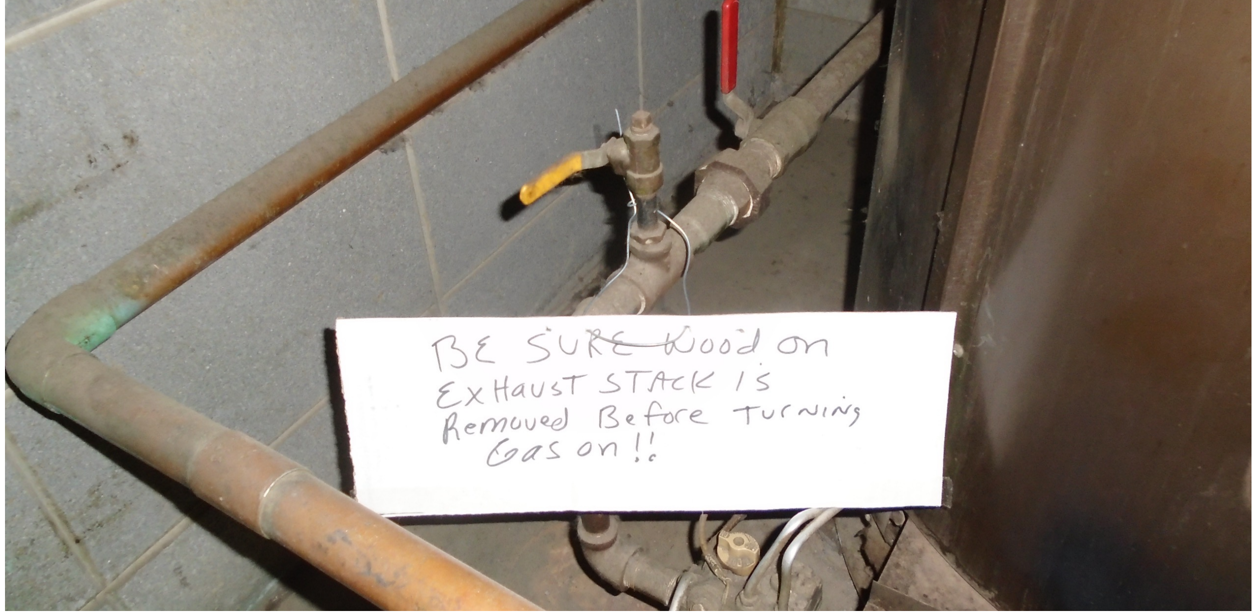
A good planned maintenance program can add **20% or more life to existing equipment**.

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.

Code Compliance

Is your equipment compliant?



The EPA began phasing out/ down refrigerants in 1990s

Initial focus was ozone depletion

Started with CFC's (R11, R12, etc.)

- Continued with HCFCs (R-22, R-500 etc) in early 2000s
- HFCs (R410A, R407C) planned to start next year

Primary focus for the last few years has been R22

- Since 2010, no new equip. could be shipped with R22
- Phaseout completed (As of 2020, NO "virgin" R-22 would be manufactured or imported)
- Available R22 would be based on supplier stockpiles and amount reclaimed by contractors, but R22 was expected to be available for servicing equipment for years.

The "Old" Strategy (12 months ago)

- Keep R22 equipment in proper operation and only replace when unit appears at or beyond useful life.
- Continue monitoring the cost of R22

The best [performing] refrigerant for R22 equip. is R22

There is no direct replacement for R22 *(i.e. you cannot simply begin adding a different refrigerant for repairs).*

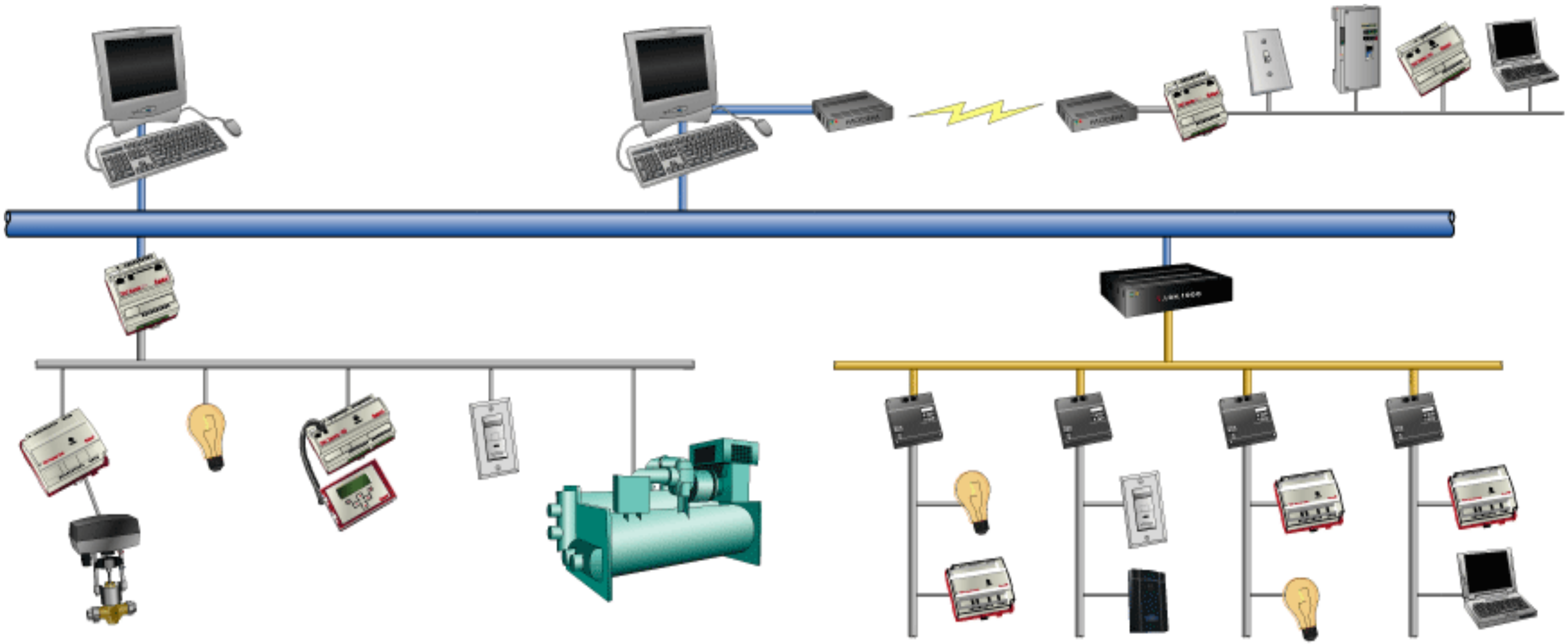
There is no R-22 "drop-in". *Equip. needs to be converted to work with an approved R22 alternative, which **WILL** have a negative impact on unit performance.*

There ARE numerous approved alternatives. *Deciding on the "right" one for your school's applications must consider performance, cost, and the likelihood of success (initial conversion and ongoing maintenance).*

Be Consistent...

- *If equipment has multiple circuits, convert them all at once.*
- *Avoid use of different alternatives at the same site.*

Controls System Obsolete



- ✓ Stand Alone Building Automation System
- ✓ Networked Building Automation System

When to update?

Answer: It depends...

- ✓ Code Compliance
- ✓ Planned Replacement
- ✓ Lifecycle Exceeded
- ✓ High Repair Costs
- ✓ Obsolescence
- ✓ Equipment no Longer Serviced
- ✓ Upcoming Building Project

Where to start

Central Plant

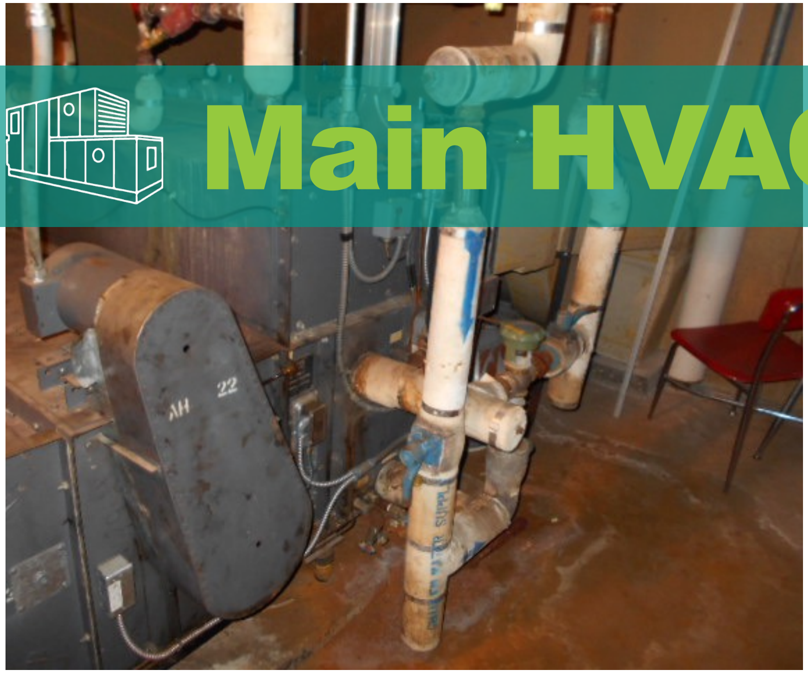
Large Equipment

System Components

Complete Systems

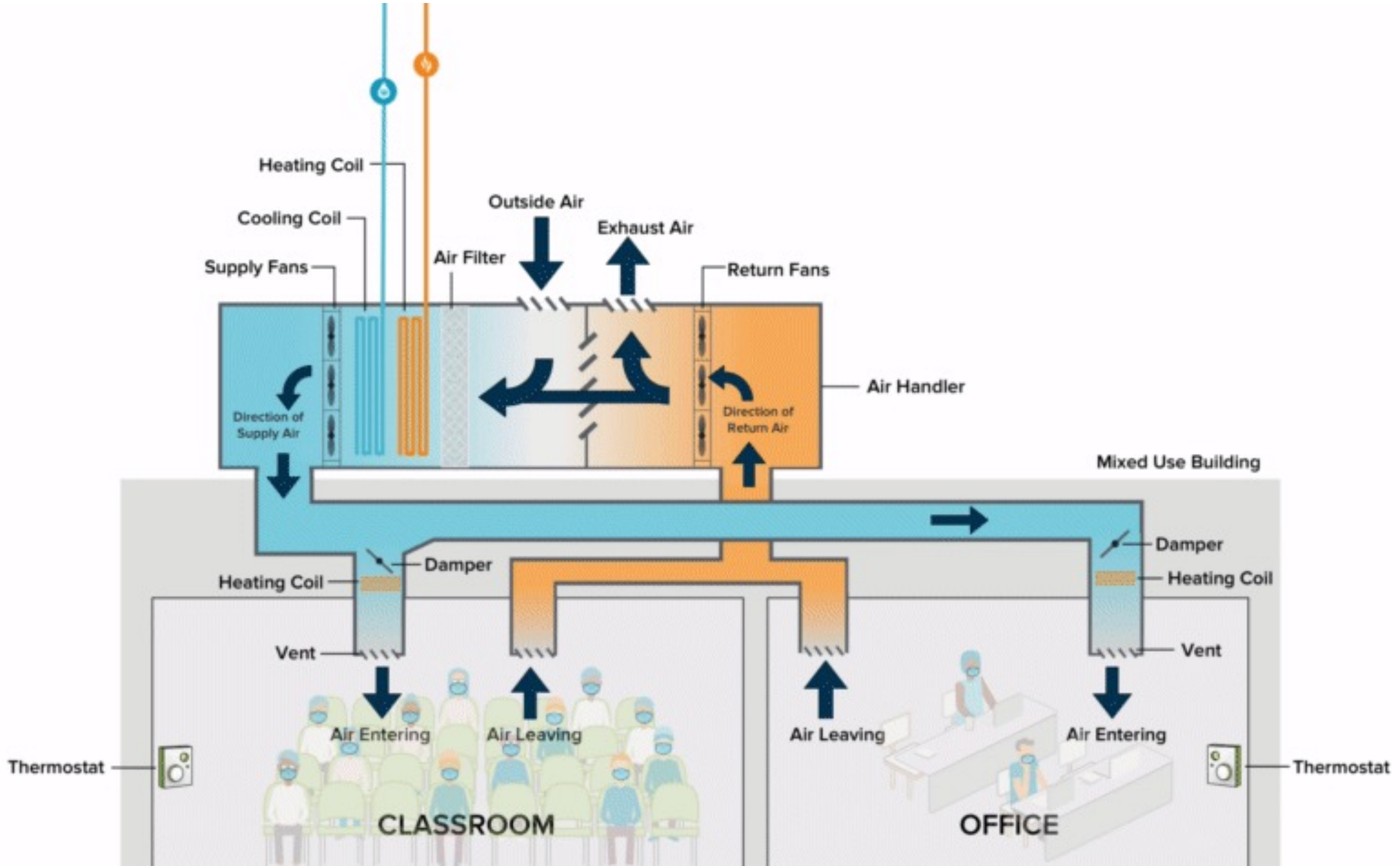
Central plant equipment

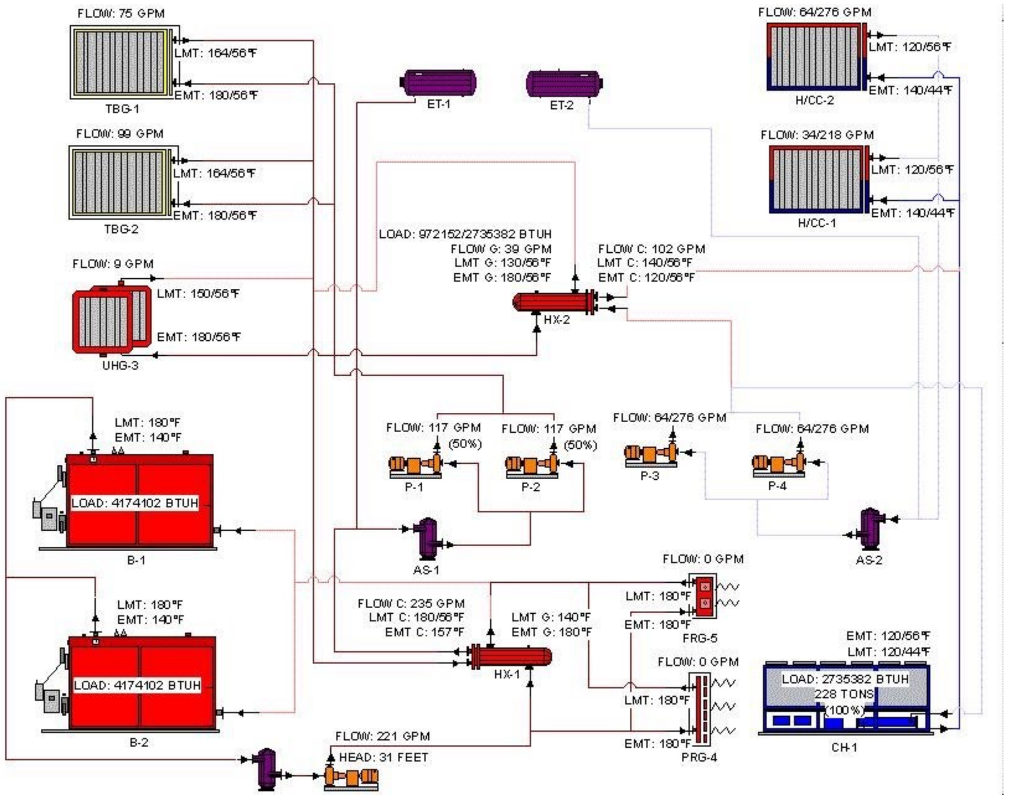
Main HVAC equipment



HVAC system components

Complete systems

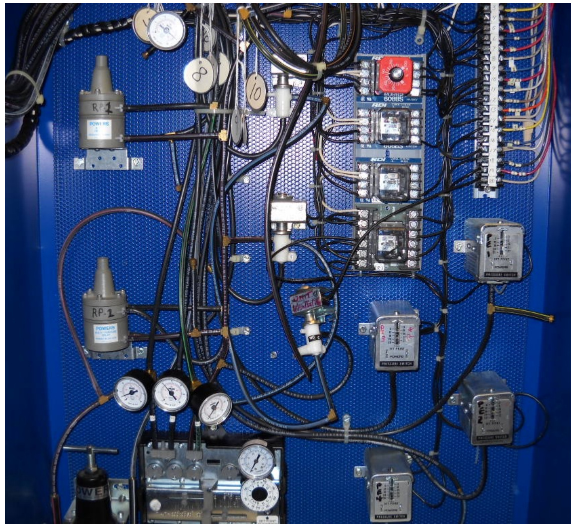


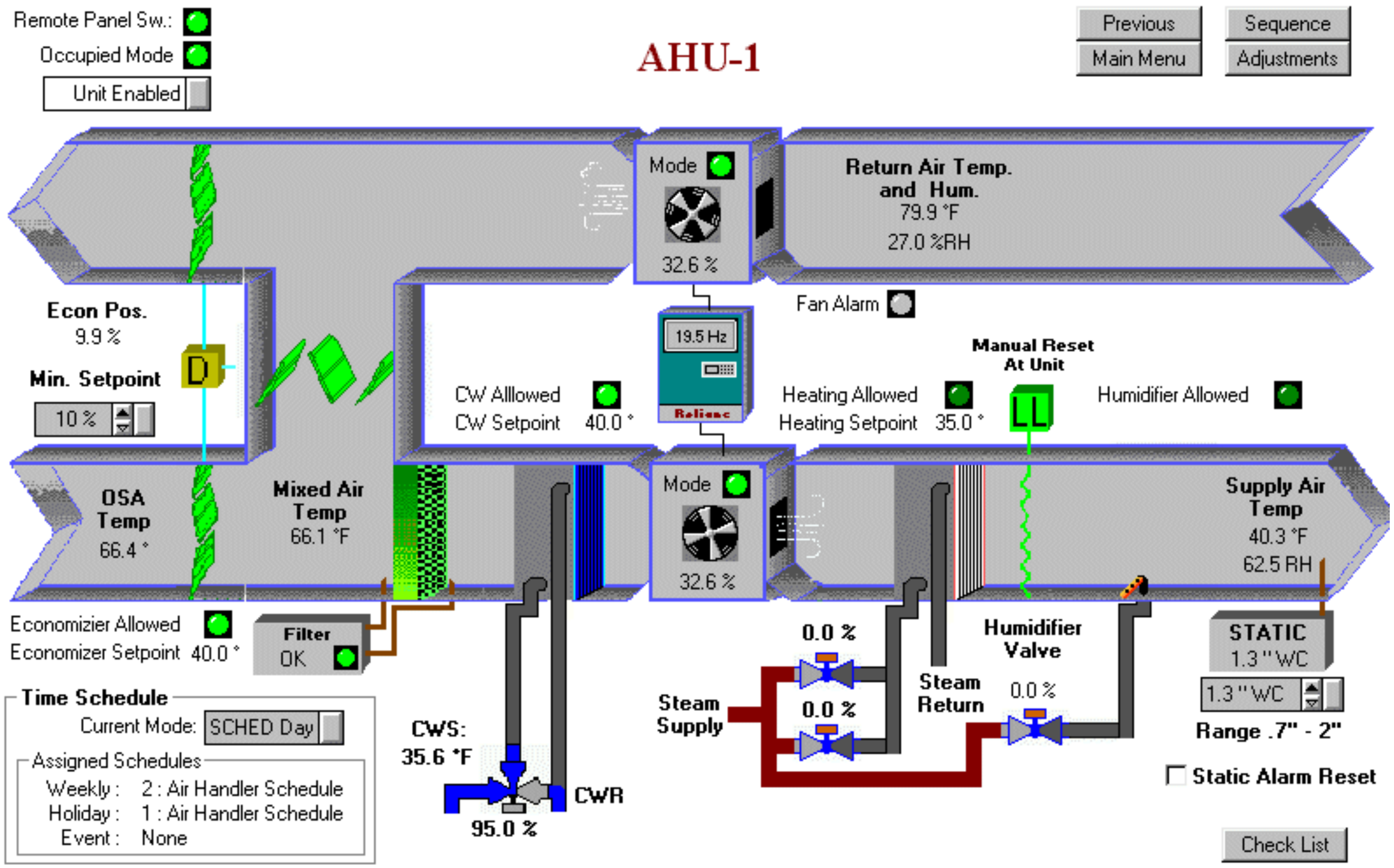


Controls systems

Pneumatic to DDC Controls System

Obsolete DDC System Architecture





Where to start conclusion

Timing is Everything!

- ✓ Equipment Failure Risk
- ✓ Available Funding
- ✓ Facility 10 Year Master planned Items
- ✓ Upcoming Building Projects

What type of system

Design Considerations

Existing Building Systems

Building Attributes

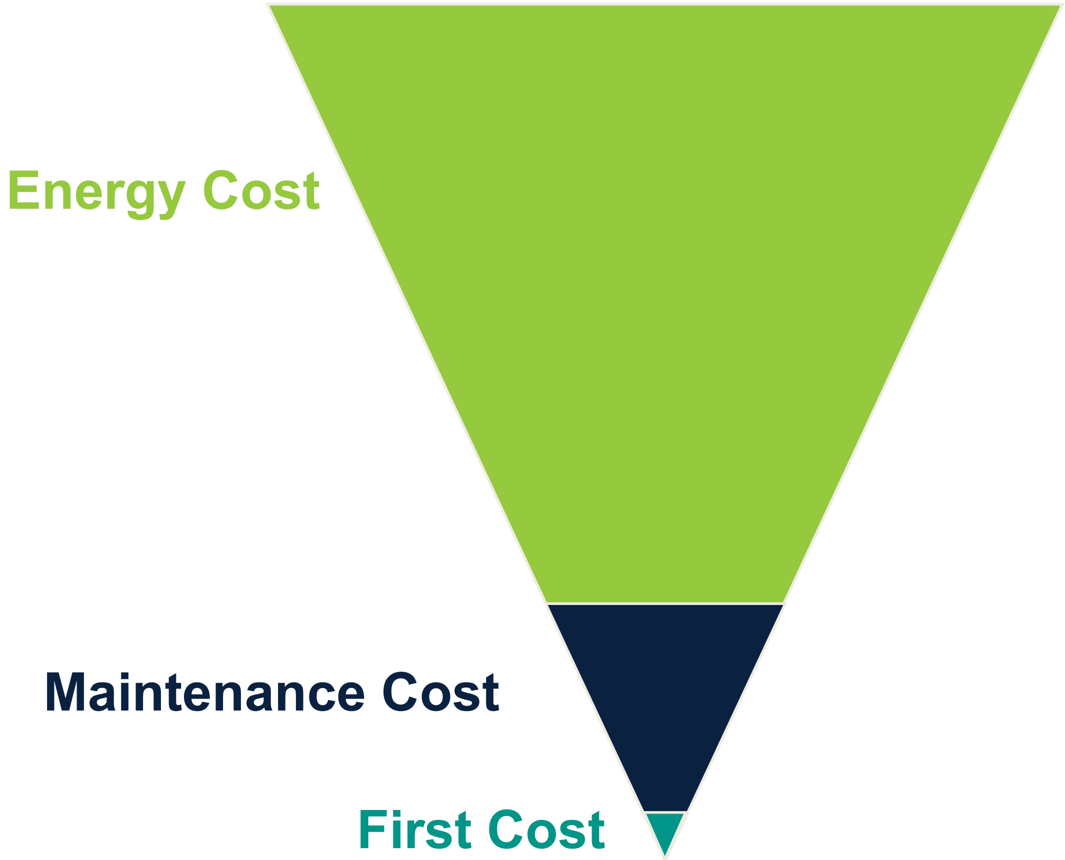
Ease of Maintenance

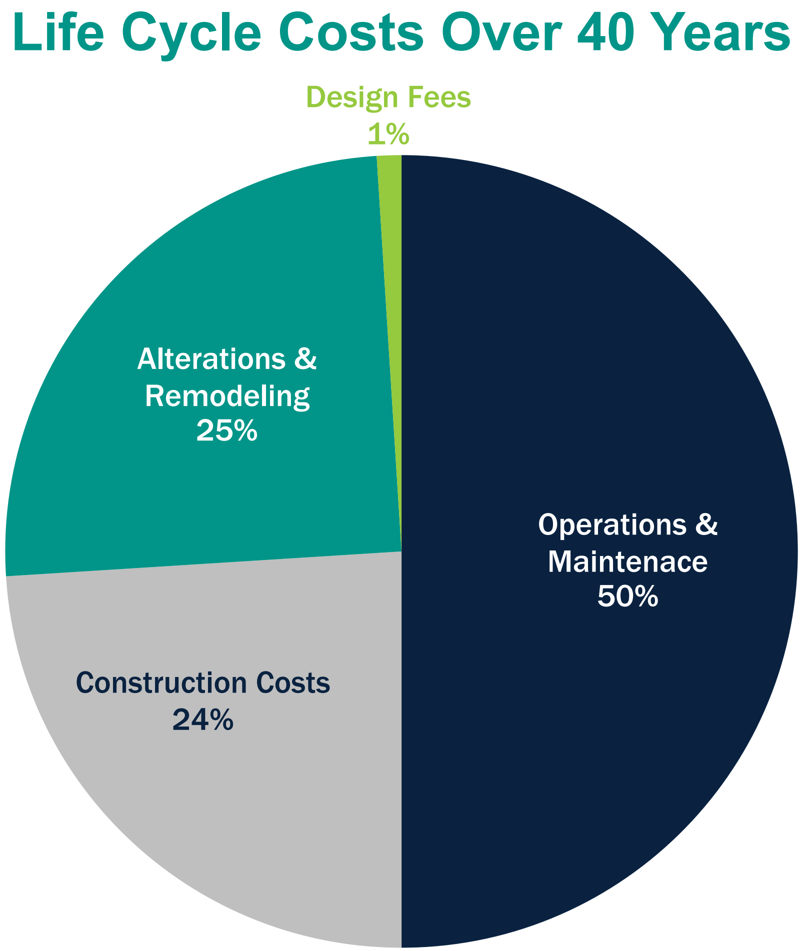
HVAC system goals

There may be a great deal of complexity surrounding mechanical systems, but the goal is easy to understand

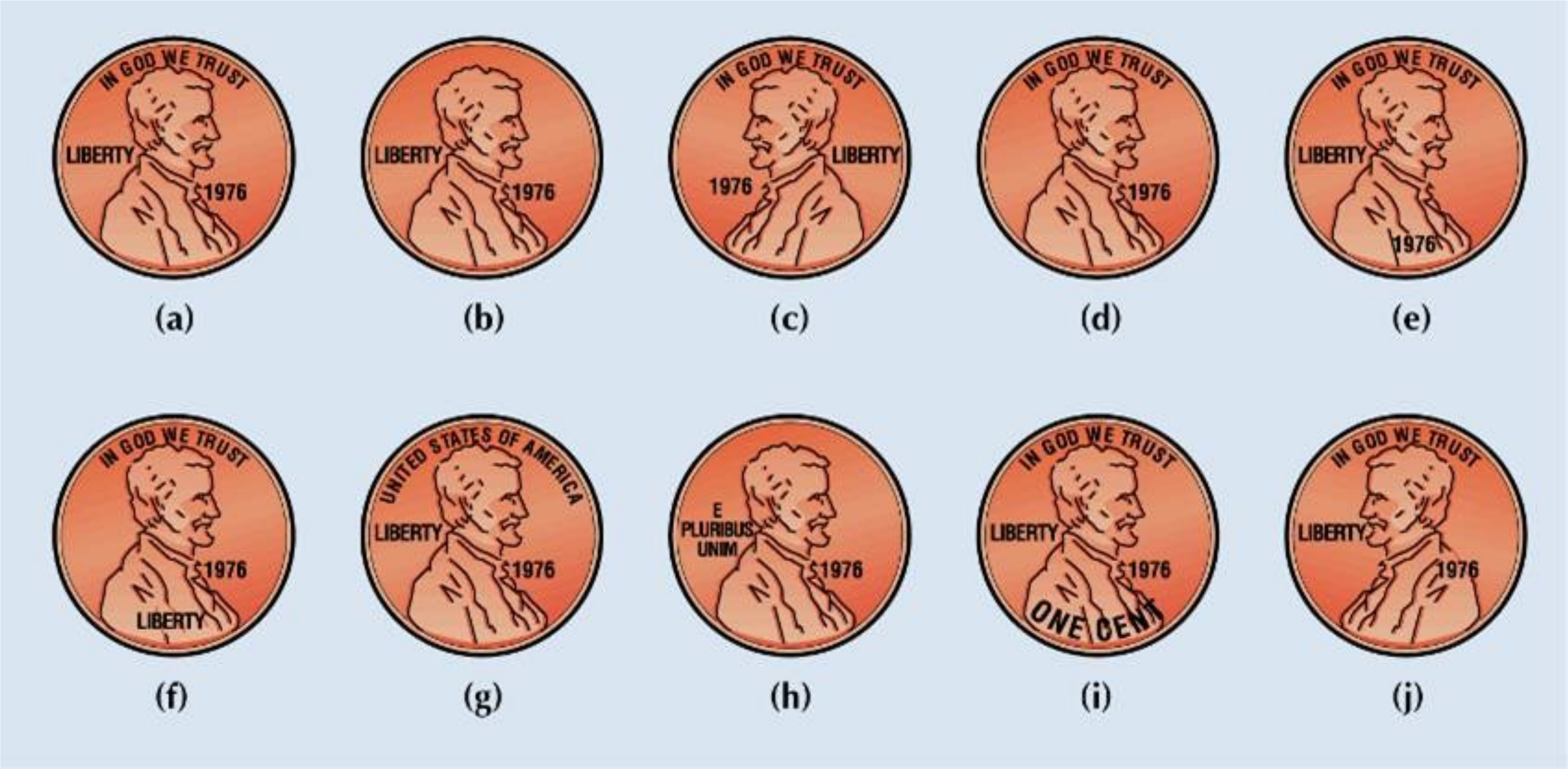
- Regulate temperature and humidity
- Circulate appropriate volumes of fresh air
- Filter contaminants from the air
- Be unobtrusive and quiet
- Operate efficiently and economically
- Provide ease of maintenance

System life cycle cost?





Know what you're looking at!



System comparison

VENTILATION SYSTEM COMPARISON

		SYSTEM CHARACTERISTICS									
		LOWER UPFRONT COST	ADDITIONAL VENTILATION CAPACITY	EASY OF ENERGY RECOVERY	INCREASED FILTRATION	LOW SYSTEM NOISE	EASE OF MAINTENACE	EXTENDED SERVICE LIFE	EXCELLENT OVERALL ENERGY EFFICIENCY	EXCELLENT OVERALL INDOOR AIR QUALITY	LOWER LIFECYCLE COST
SYSTEM TYPE	CLASSROOM UNIT VENTILATORS	X									
	GAS FIRED ROOFTOP / DX COOLING	X	X								
	INDOOR AHU / VAV REHEAT		X	X	X	X	X	X	X	X	X
	INDOOR ENERGY RECOVERY / DISPLACEMENT		X	X	X	X	X	X	X	X	X

Building Attributes

Tagline here

Budget tolerance of School Board

Amount of addition vs. size of existing building

Available floor to ceiling height

Building footprint, single-story with a sprawling footprint

Existing HVAC system capacity

Ease of Maintenance

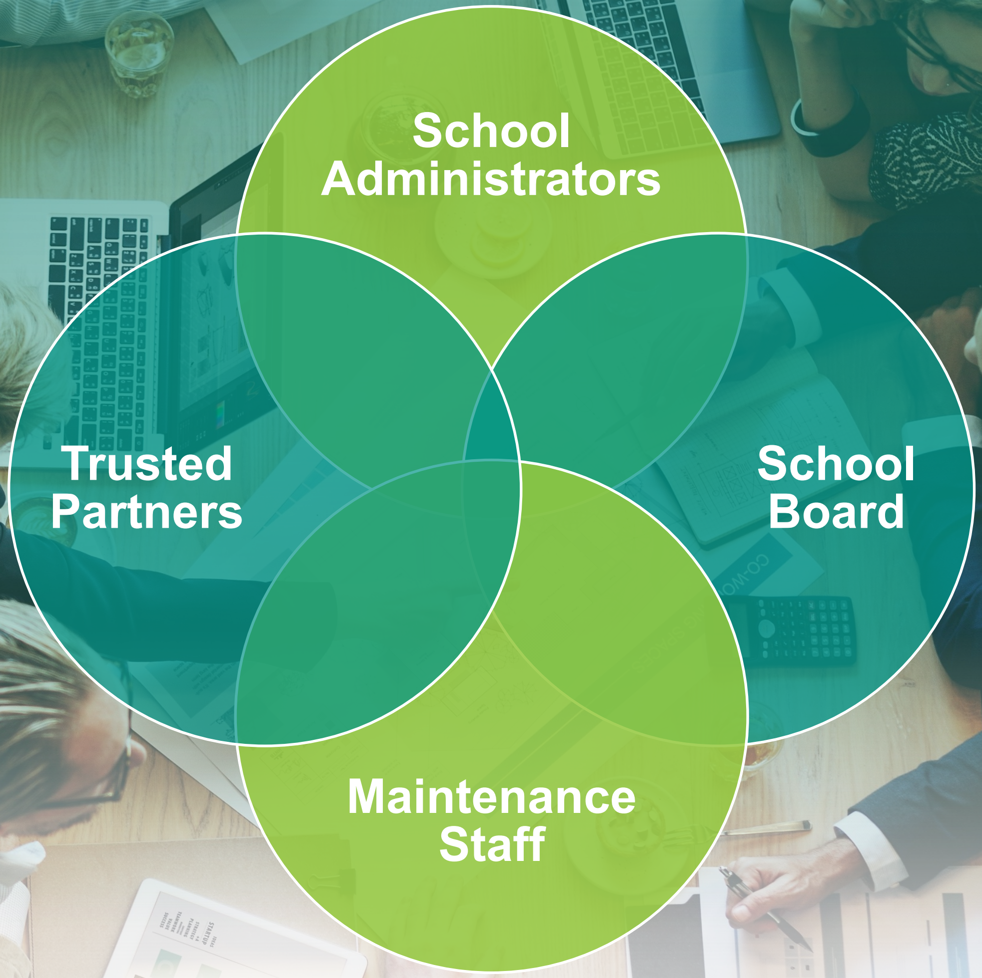
And this...

What type of system conclusion

Think Through Your Decision.....

After all it‘s a 20-40 Year Decision

Who is on your team?



In summary

why

- ✓ Improved Equipment Operation
- ✓ Reduced Maintenance
- ✓ Improved Efficiency
- ✓ Improved Indoor Air Quality and Filtration
- ✓ Students in well-maintained facilities do better and feel better

when

- ✓ Code Compliance
- ✓ Planned Replacement
- ✓ Lifecycle Exceeded
- ✓ High Repair Costs
- ✓ Obsolescence
- ✓ Equipment no Longer Serviced
- ✓ Upcoming Building Project

where

- ✓ Central Plants (Boilers, Chillers, Condensing Units)
- ✓ Large Equipment
- ✓ System Components
- ✓ Complete Systems
- ✓ Equipment Failure Risk
- ✓ Available Funding
- ✓ Facility 10 Year Masterplan Items
- ✓ Upcoming Building Projects

what

- ✓ Design considerations (IAQ, Comfort, Lifecycle cost of Ownership, Energy Efficiency)
- ✓ Existing Building Systems
- ✓ Building Attributes
- ✓ Ease of Maintenance
- ✓ Think through your 20-40 year decision

who

- ✓ School Administrators
- ✓ School Board
- ✓ Maintenance Staff
- ✓ Trusted Partners

Questions?

NEXUS SOLUTIONS®

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