CEM|CEA

HEATING, VENTILATING AND AIR CONDITIONING (HVAC) SYSTEM

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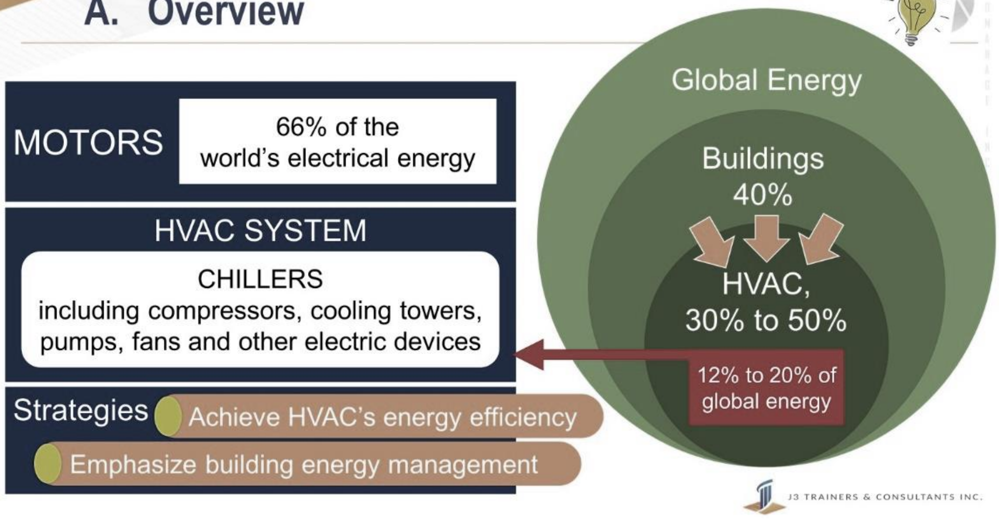
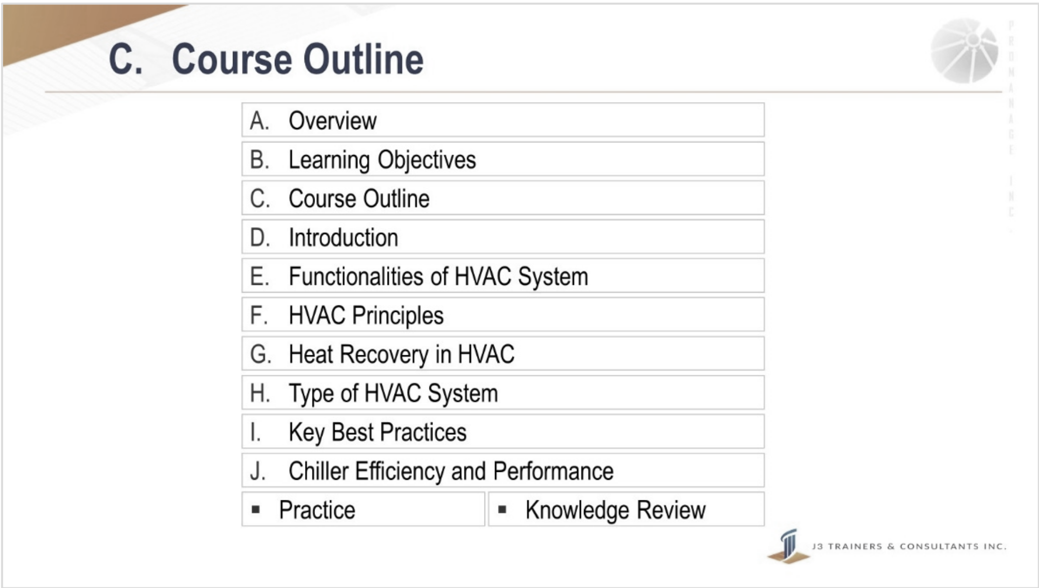
A. Overview



B. Learning Objectives

At the end of this course you will be able to:

- Understand the HVAC system; its functionalities, components, and types used in the industry;
- Review the principles applied in HVAC and recognize their influences to energy usage;
- Identify best practices and learn key calculations on HVAC efficiencies and performances, and;
- Apply the knowledge about the effects of HVAC to energy usage to developing energy management programs.


C. Course Outline
A. Overview
B. Learning Objectives
C. Course Outline
D. Introduction
E. Functionalities of HVAC System
F. HVAC Principles
G. Heat Recovery in HVAC
H. Type of HVAC System
I. Key Best Practices
J. Chiller Efficiency and Performance
▪ Practice
▪ Knowledge Review
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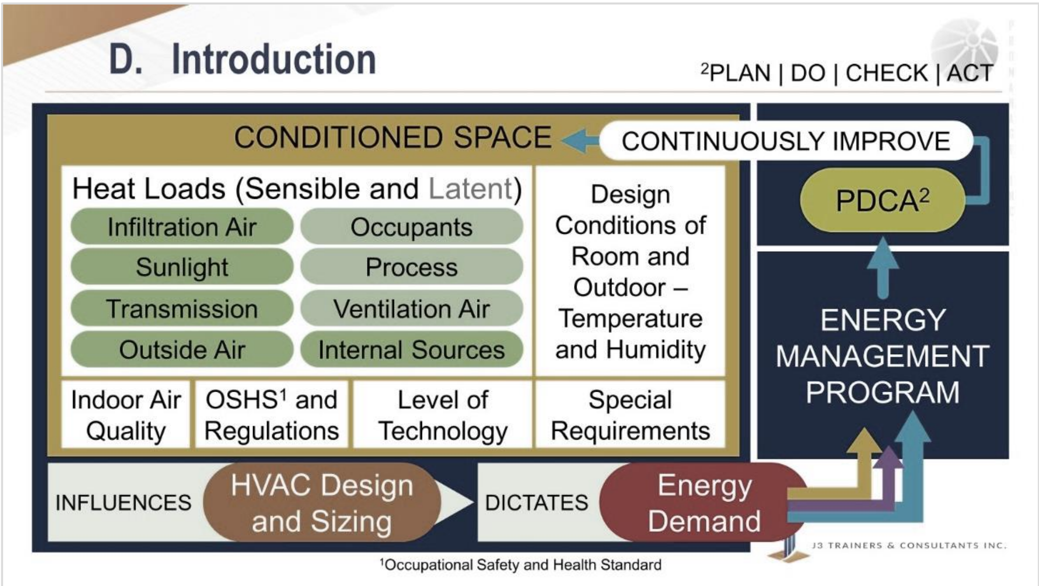
D. Introduction
2PLAN | DO | CHECK | ACT
CONDITIONED SPACE
CONTINUOUSLY IMPROVE
Heat Loads (Sensible and Latent)
Infiltration Air
Occupants
Sunlight
Process
Transmission
Ventilation Air
Outside Air
Internal Sources
Design Conditions of Room and Outdoor – Temperature and Humidity
PDCA2
ENERGY MANAGEMENT PROGRAM
Indoor Air Quality
OSHS1 and Regulations
Level of Technology
Special Requirements
INFLUENCES
HVAC Design and Sizing
DICTATES
Energy Demand
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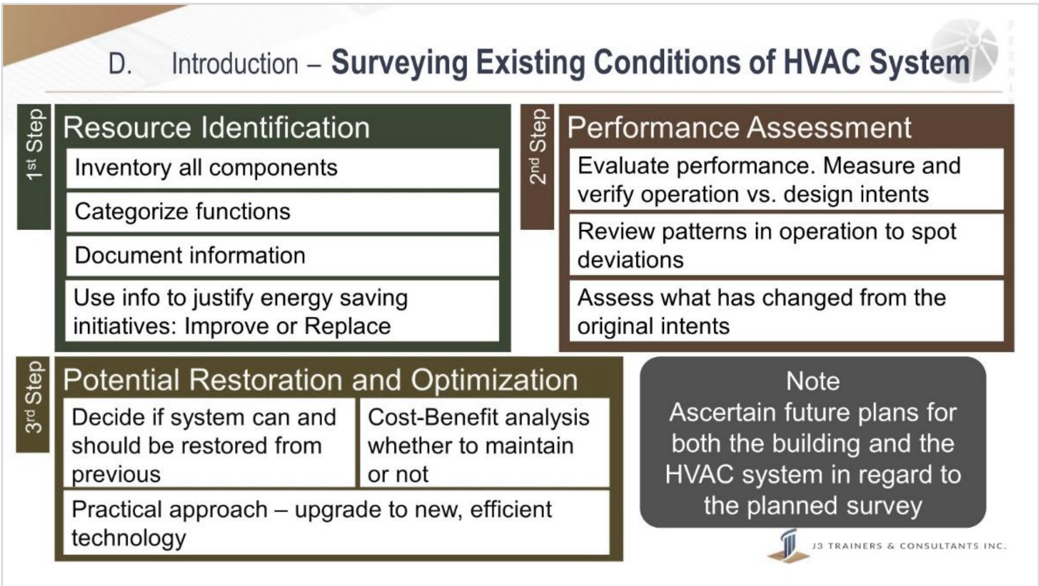
1Occupational Safety and Health Standard


D. Introduction – Surveying Existing Conditions of HVAC System
1st Step
Resource Identification
Inventory all components
Categorize functions
Document information
Use info to justify energy saving initiatives: Improve or Replace
2nd Step
Performance Assessment
Evaluate performance. Measure and verify operation vs. design intents
Review patterns in operation to spot deviations
Assess what has changed from the original intents
3rd Step
Potential Restoration and Optimization
Decide if system can and should be restored from previous
Cost-Benefit analysis whether to maintain or not
Practical approach – upgrade to new, efficient technology
Note
Ascertain future plans for both the building and the HVAC system in regard to the planned survey
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E. Functionalities of HVAC System

1	Heating	▪ Provides warmth during colder months by controlling the temperature using a furnace, boiler, or heat pump.
2	Ventilating	▪ Ensures the circulation of fresh air by removing stale air, odors, and airborne pollutants. ▪ Brings in outside air and exhausts indoor air to create a healthy environment.
3	Air Conditioning	▪ Cools the indoor space by extracting heat and moisture through a refrigeration cycle. ▪ Controls the temperature to a comfortable level during hotter months.

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E. Functionalities of HVAC System

4	Humidity Control	▪ Maintains the optimal humidity level in indoor environment. ▪ Removes excess moisture during humid conditions and adds moisture during dry conditions.
5	Air Filtration	▪ Filters the air, removing dust, allergens, pollutants, and other particles. ▪ Improves indoor air quality, reduces health risks.
6	Energy Efficiency	▪ Designed to be energy-efficient, helping to reduce energy consumption and lower utility bills. ▪ Often with programmable thermostats and energy-saving features to optimize performance.

E. Functionalities of HVAC System - **HVAC System Components**

Consist of various components that work together to regulate temperature, humidity, and air quality in buildings

The specific components may vary based on the type of HVAC system and its intended application, but generally include the following:

CHILLER UNIT

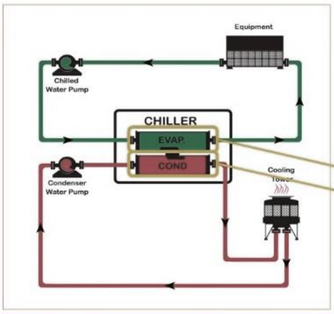
COOLING TOWER

- Compressor
- Evaporator Coil
- Condenser Coil
- Thermostat
- Heat Exchanger
- Refrigerant Lines
- Thermal Expansion Valve

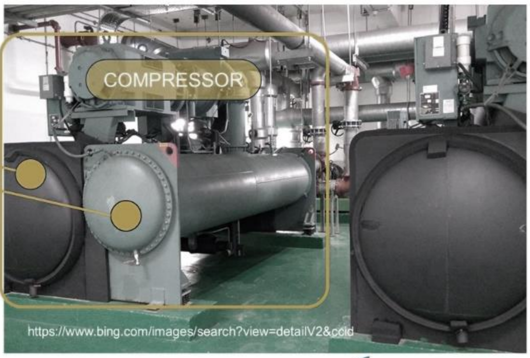
- Ductwork
- Air Handlers
- Ventilation Fans
- Air Filters
- Zone Dampers
- Humidifiers
- Furnace or Boiler

E. Functionalities of HVAC System - **HVAC System Components**

Chiller Units



Water-cooled Chiller



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E. Functionalities of HVAC System - **HVAC System Components**

Chiller Units

Sophisticated cooling system. Designed to remove heat from a liquid, typically water, and then circulate the chilled liquid through a building or facility to absorb heat

Essentially, the backbone of many large-scale air conditioning systems, ensuring spaces remain cool and comfortable

Chiller works using a refrigeration cycle, where heat is transferred from the liquid to the ambient air or to cooling medium, such as water

Ideal for various applications, from cooling commercial building to facilitating industrial processes

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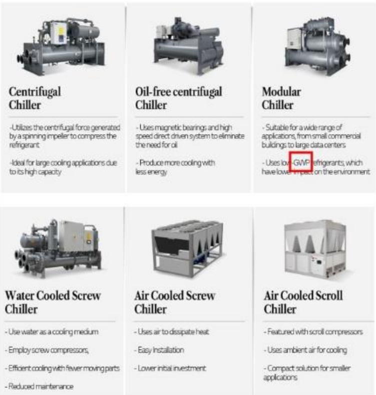
E. Functionalities of HVAC System - **HVAC System Components**

Type of Chillers

- Different types with each type having unique properties and functionality
- Each chiller is tailored to specific needs and adapted to various uses and environment



Global Warming Potential refrigerant – impact of the quantity of CO_2 over 100-year period (HFO AND HCFO)

Source: The basics of chillers and how they work | Business | LG Global

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E. Functionalities of HVAC System - HVAC System Components

Features of Chilled Water System

Energy Efficiency	Very efficient way to cool large spaces, saving energy costs compared to other cooling systems, such as direct expansion system
Scalability	Can meet the needs of buildings and facilities of all sizes, can be easily expanded or downsized as needed
Zoning	Chilled water flow network can easily and economically be distributed and operationally managed per area
Reduced maintenance requirements	Typically require less maintenance than other cooling systems thus, saving money and time over the life of the system
Suitability	Specific application depending on factors like the cooling load, local climate conditions, budget, and energy efficiency goal can be adapted to suit the system

Chilled Water System

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E. Functionalities of HVAC System - HVAC System Components

Cooling Tower

Device that rejects waste heat to the atmosphere through the cooling of a coolant stream, usually a water stream, to a lower temperature

- Uses the evaporation of water to remove heat and cool the working fluid to near the wet bulb air temperature
- The fill media within the cooling tower slows down the water flow and maximizes the surface area for efficient air-water interaction (evaporation)

https://en.wikipedia.org/wiki/Cooling_tower#/media/File:Evaporative_Cooling_Tower.jpg

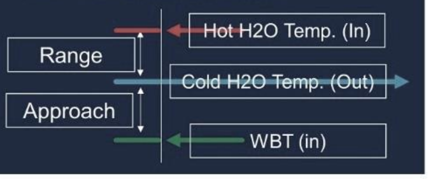
E. Functionalities of HVAC System - HVAC System Components

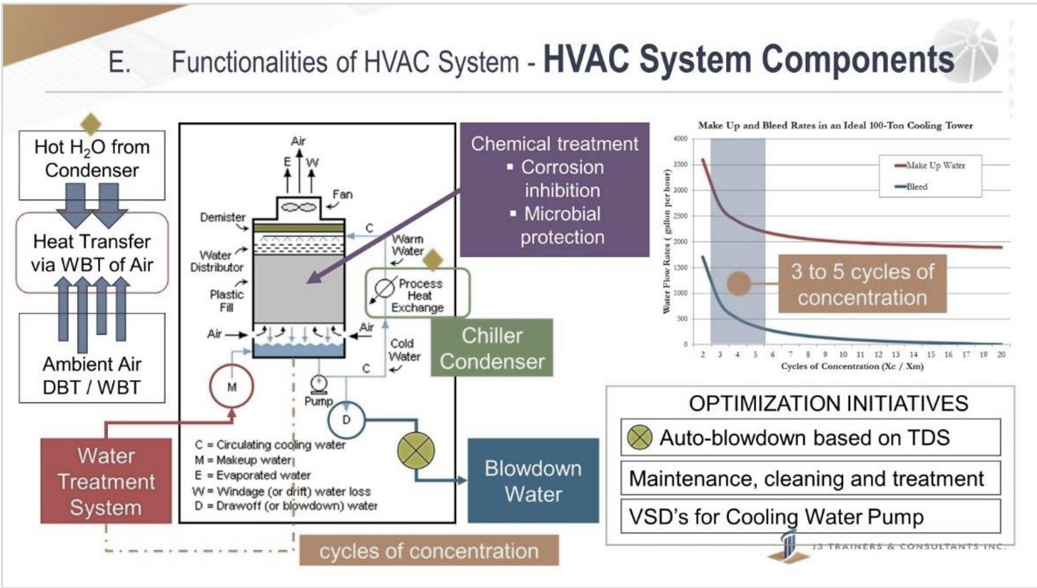
Air Flow Generation Methods

- Natural draft
- Mechanical drafts – uses power-driven fan motors to force or draw air through the tower
- Induced draft – pulls air up through tower, reduce possibility of recirculation of discharge air
- Forced draft – forces air into the tower at high static pressure and use in confined spaces
- Fan assisted natural draft – hybrid type that appears like a natural draft setup, through airflow assisted by a fan

Factors Influencing the Efficiency of a Cooling

- Range – temp. difference between the hot water inlet (from condenser) and cold water (basin) outlet at tower
- Heat load
- Ambient wet bulb temp. (WBT) or RH
- Approach – the difference between the cold water (basin) temp. and WBT, ~5 °F to 9 °F, the lower the better




E. Functionalities of HVAC System - HVAC System Components
Hot H2O from Condenser
Heat Transfer via WBT of Air
Ambient Air DBT / WBT
Water Treatment System
Air
E W
Fan
Demister
Water Distributor
Plastic Fill
Air
Warm Water
Process Heat Exchange
Cold Water
Pump
C = Circulating cooling water
M = Makeup water
E = Evaporated water
W = Windage (or drift) water loss
D = Drawoff (or blowdown) water
Chemical treatment
▪ Corrosion inhibition
▪ Microbial protection
Chiller Condenser
Blowdown Water
cycles of concentration
Make Up and Bleed Rates in an Ideal 100-Ton Cooling Tower
Water Flow Rates (gallon per hour)
Cycles of Concentration (Xc / Xm)
Make Up Water
Bleed
3 to 5 cycles of concentration
OPTIMIZATION INITIATIVES
Auto-blowdown based on TDS
Maintenance, cleaning and treatment
VSD's for Cooling Water Pump
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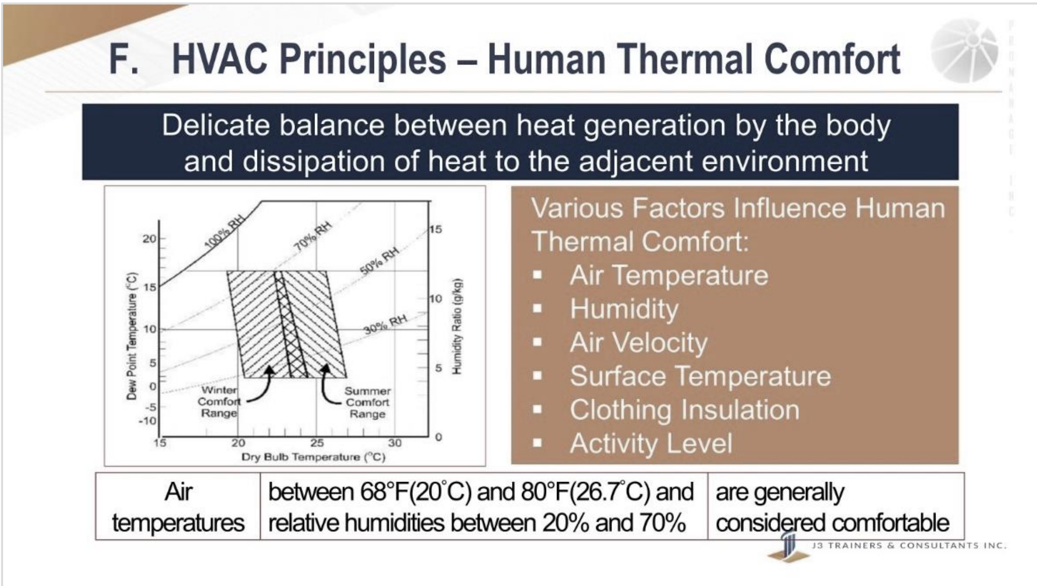
F. HVAC Principles – Human Thermal Comfort
Delicate balance between heat generation by the body and dissipation of heat to the adjacent environment
100% RH
70% RH
50% RH
30% RH
Dew Point Temperature (°C)
Humidity Ratio (g/kg)
Winter Comfort Range
Summer Comfort Range
Dry Bulb Temperature (°C)
Various Factors Influence Human Thermal Comfort:
▪ Air Temperature
▪ Humidity
▪ Air Velocity
▪ Surface Temperature
▪ Clothing Insulation
▪ Activity Level
Air temperatures
between 68°F(20°C) and 80°F(26.7°C) and relative humidities between 20% and 70%
are generally considered comfortable
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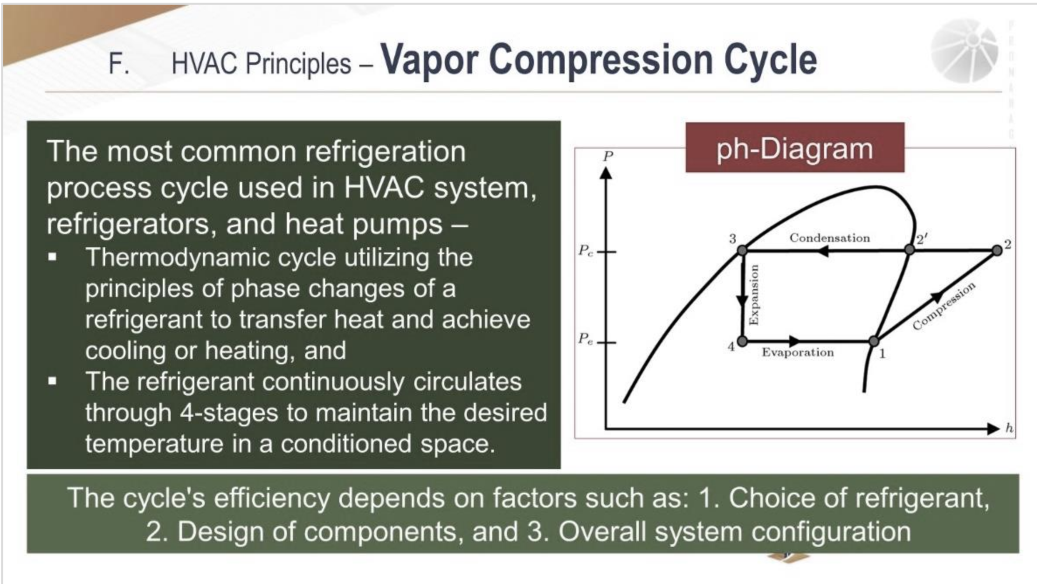
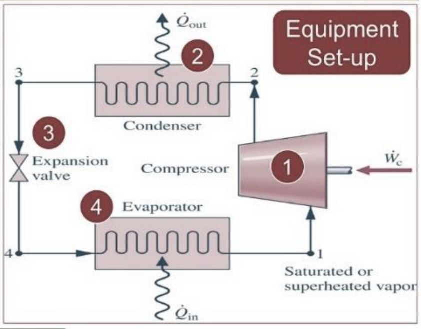

F. HVAC Principles – Vapor Compression Cycle
The most common refrigeration process cycle used in HVAC system, refrigerators, and heat pumps –
▪ Thermodynamic cycle utilizing the principles of phase changes of a refrigerant to transfer heat and achieve cooling or heating, and
▪ The refrigerant continuously circulates through 4-stages to maintain the desired temperature in a conditioned space.
ph-Diagram
P
Pc
Pe
h
Condensation
Expansion
Evaporation
Compression
1
2
2'
3
4
The cycle's efficiency depends on factors such as: 1. Choice of refrigerant, 2. Design of components, and 3. Overall system configuration

F. HVAC Principles – Vapor Compression Cycle

The foundation for most air conditioning and refrigeration systems due to its efficiency and effectiveness in heat transfer

Allow for the controlled and repeated transfer of heat from one location to another

Compressor (1)	Increases the pressure and temperature of the refrigerant vapor
Condenser (2)	Releases heat from the refrigerant to the environment, causing the refrigerant to condense into a liquid
Expansion Valve (3)	Reduces the temperature and pressure of liquid refrigerant, creating a mixture of liquid and vapor
Evaporator (4)	Absorbs heat from the space being cooled, thus evaporating the liquid refrigerant back to vapor



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F. HVAC Principles – Sensible Heat

Refers to the heat energy that causes a change in temperature of a substance without any phase change.

- It is the heat that can be felt or measured by a thermometer.
- Typically measured in units of energy, such as joules or calories.

EXAMPLE: When you heat a metal rod on a stove, and the rod becomes hot to the touch, the heat transferred to the rod is sensible heat.
The temperature of the rod increases, but it remains in the same phase (solid).

$$Q_s = 1.08 \times \text{Air Flow Rate} \times \Delta T$$

where:

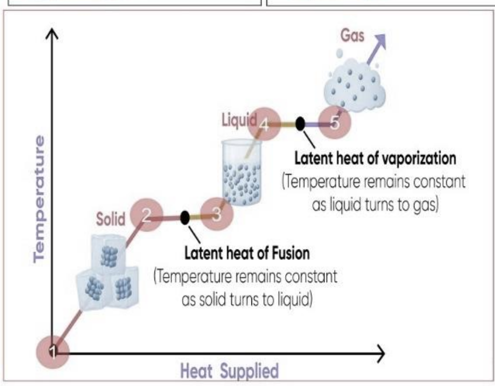
Q_s	= sensible cooling load (Btu/hr)
1.08	= specific heat of air (constant)
Air Flow Rate	= the rate of air circulation (cfm)
ΔT	= difference bet. entering and leaving air temperature (*deg-F*)

F. HVAC Principles – Latent Heat

Refers to the heat energy that is absorbed or released during a phase change

- Example: Melting, freezing, evaporation, condensation) without a change in temperature.
- Latent heat is typically measured in units of energy per unit mass, such as joules per kilogram.

1 to 2 3 to 4	Sensible Heat
2 to 3 4 to 5	Latent Heat



F. HVAC Principles – Latent Heat

EXAMPLE: When ice melts into water at 0 degrees Celsius, the heat energy absorbed during this phase change is latent heat. The temperature remains constant during the phase change.

$$Q_l = 0.68 \times \text{Air Flow Rate} \times \Delta H$$

where:

Q_l	= the Latent cooling load Btu/hr or watts)
0.68	= the latent heat of vaporization for water (constant)
Air Flow Rate	= the rate of air circulation (cfm)
ΔT	= difference bet. entering and leaving air humidity ratios

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G. Heat Recovery in HVAC

- Refers to the process of capturing and reusing thermal energy that would otherwise be wasted
- This energy recovery technique is designed to improve the overall energy efficiency of HVAC systems by recovering heat from the exhaust air stream and using it to preheat or precool the incoming fresh air
- Heat recovery is particularly valuable in climates where there are significant temperature differences between the outdoor and indoor air

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G. Heat Recovery in HVAC – Type of Heat Recovery System

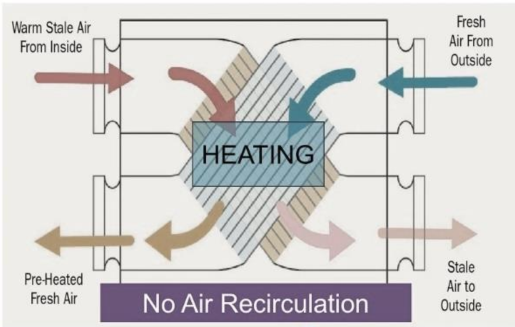
Two main types of heat recovery systems commonly used in HVAC

1. Sensible Heat Recovery
2. Latent Heat Recovery

1. Sensible Heat Recovery

Involves in transferring the temperature difference (sensible heat) between the exhaust air and the fresh air

This is achieved through devices known as heat exchangers.



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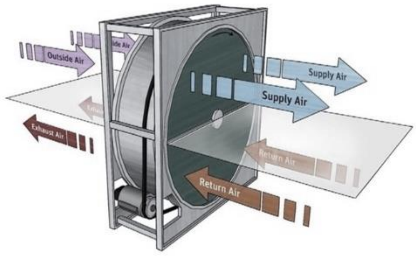
G. Heat Recovery in HVAC – Type of Heat Recovery System

2. Latent Heat Recovery

- Captures the moisture or humidity from the exhaust air and transferring it to the incoming fresh air
- Key in humid climates where the latent load (moisture content) of the air is significant
- Heat recovery is achieved by using enthalpy wheels or other specialized heat exchangers



Heat Recovery Wheels
Source from Web

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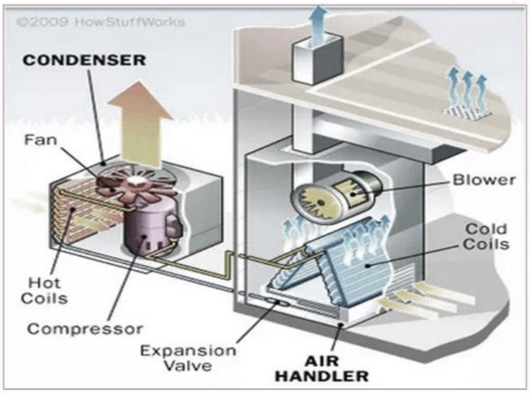
H. Type of HVAC System

Split Air Conditioner

- This system has separate indoor and outdoor units
  - Indoor unit has the evaporator coil and air handler
  - Outdoor unit houses the compressor and condenser coil
- These systems are commonly used in residential and small commercial buildings



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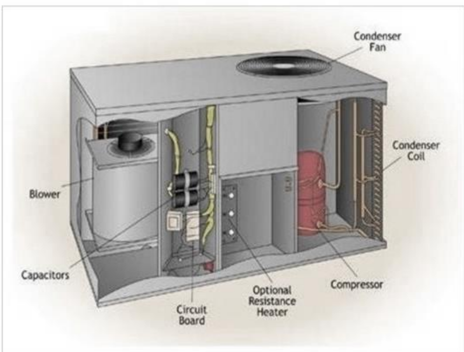
H. Type of HVAC System

Packaged Conditioner

- All components, including the compressor, evaporator, and condenser, are housed in a single unit, typically installed on the roof or a concrete slab near the building
- Commonly used in commercial buildings with limited indoor space



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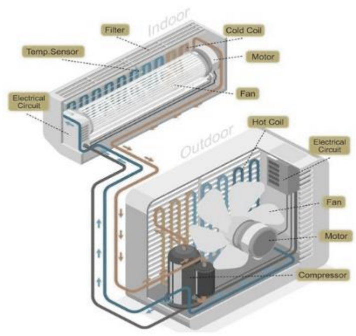
H. Type of HVAC System

Ductless Mini-split System

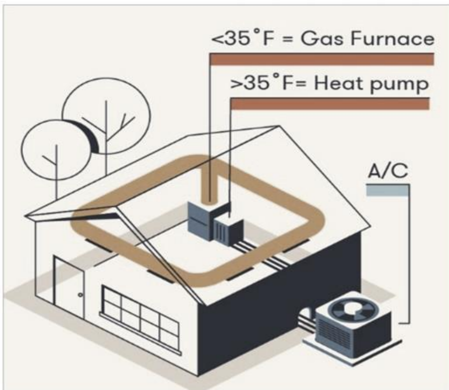
- Similar to split systems, but without the need for ductwork
- Consist of an outdoor compressor / condenser unit and one or more indoor air handling units
- Suitable for individual room heating and cooling, often used in home additions or areas without existing ductwork



H. Type of HVAC System

Hybrid HVAC System

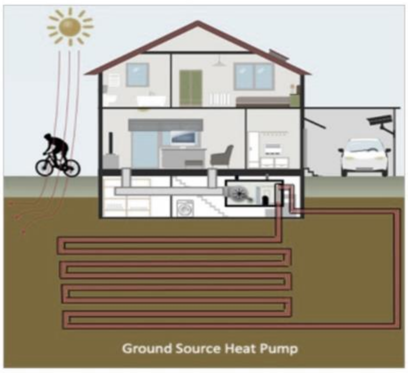
- Combines a traditional furnace with a heat pump
- The system automatically switches between the two heat sources based on outdoor temperatures, optimizing energy efficiency



H. Type of HVAC System

Geothermal Heating and Cooling System

- Utilizes the stable temperature of the ground to exchange heat with the building
- Highly energy-efficient but with higher upfront installation costs



H. Type of HVAC System

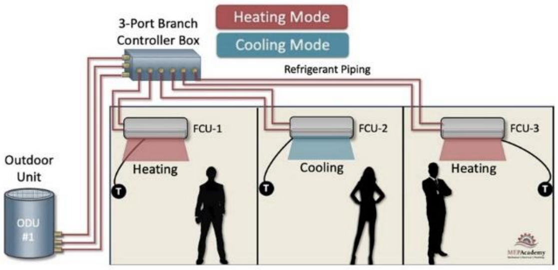
Radiant Heating System

- Heats the building by circulating warm water through tubing or pipes in the floor, walls, or ceiling
- Provides comfortable and even heat distribution

H. Type of HVAC System

VRF (Variable Refrigerant Flow) System

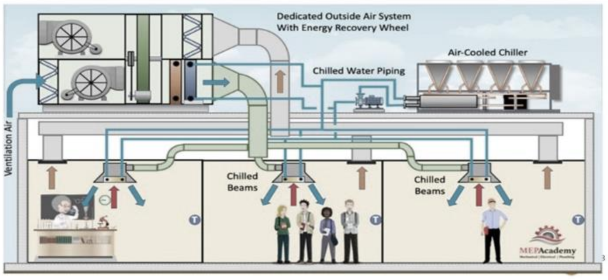
- Suitable for larger buildings, VRF systems use refrigerant as the heat exchange medium and allow for variable control of indoor units
- Known for their energy efficiency and zoning capabilities



H. Type of HVAC System

Chilled Beam System

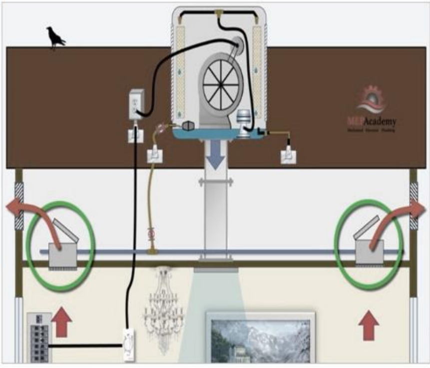
- Commonly used in commercial buildings, chilled beam systems use convection and water-based cooling to regulate the indoor temperature



H. Type of HVAC System

Evaporative Cooling System

Cools air by passing it over water-saturated pads, providing an energy-efficient alternative to traditional air conditioning in dry climates.



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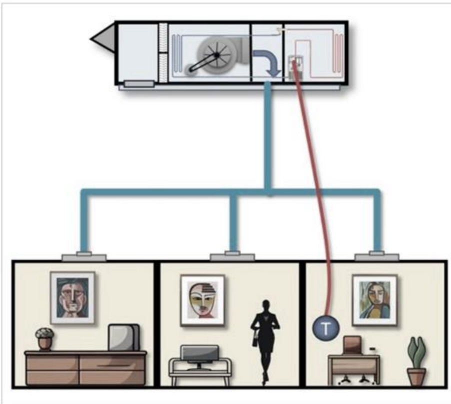
Type of HVAC System

Constant Air Volume (CAV) System

Maintains constant airflow rate while adjusting the temperature to meet the heating or cooling demands



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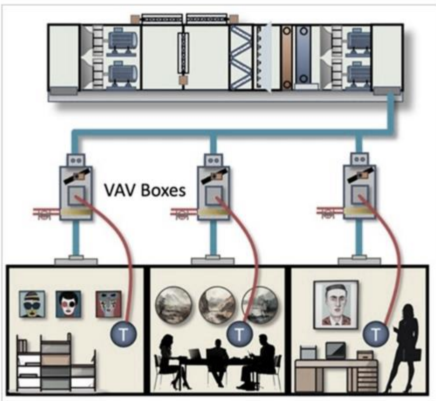
H. Type of HVAC System

Variable Air Volume (VAV) System

Adjusts both the airflow and temperature based on the heating or cooling requirements of different zones in a building



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I. Key Best Practices

#	Practice
1	**Regular Maintenance** ▪ Scheduled Inspections ▪ Proactive Repairs
2	**Proper System Sizing and Design** ▪ Right-Sizing Equipment ▪ Ductwork Design
3	**Energy-Efficient Equipment** ▪ High-Efficiency Systems ▪ Variable Speed Drives

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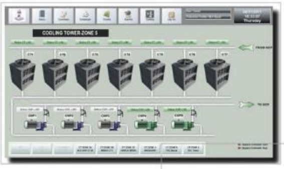
I. Key Best Practices

4 Building Automation and Controls

- Building Management System (BMS)



- Smart Sensors

5 Setpoint Optimization

- Temperature Setpoints
  Optimize temperature setpoints for different zones based on occupancy and comfort requirements
- Night Setback
  Implement setback strategies during unoccupied hours to reduce energy consumption

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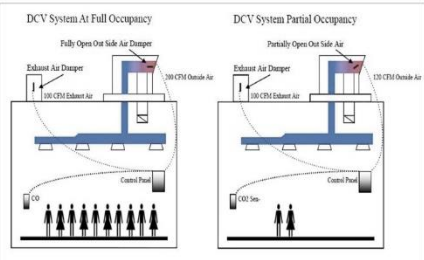
I. Key Best Practices

6 **Demand-Controlled Ventilation**

- CO2 Sensors
- Air Quality Monitoring



7 **Zoning & Individual Space Controls**

- Zoning Systems

- Occupancy Sensors

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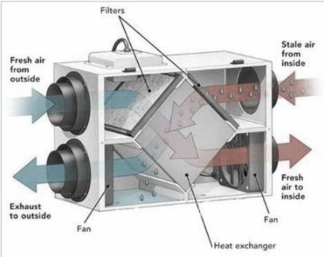
I. Key Best Practices

8	**Energy Recovery** Energy Recovery Ventilators (ERVs) or Heat Recovery Ventilators (HRVs)

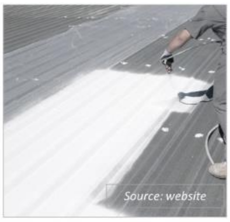


9	**Renewable and Alternative Energy Integration** • Solar Technologies: Integrate solar thermal systems or PV panels to generate renewable energy for HVAC needs • Geothermal Systems: Consider geothermal heat pumps for efficient heating and cooling

I. Key Best Practices

10 Building Envelop Improvements

- Insulation



- Air Sealing

11 Occupant Engagement and Education

- Occupant Training
- Feedback Systems

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I. Key Best Practices

11	Performance Monitoring and Benchmarking ▪ Regular Monitoring: Continuously monitor HVAC system performance using energy meters and sensors. ▪ Benchmarking: Compare energy usage against industry benchmarks to identify areas for improvement.
12	Energy Audits ▪ Regular Audits: Conduct regular energy audits to identify inefficiencies and opportunities for improvement. ▪ Professional Assistance: Seek the expertise of energy professionals to perform comprehensive energy assessments.

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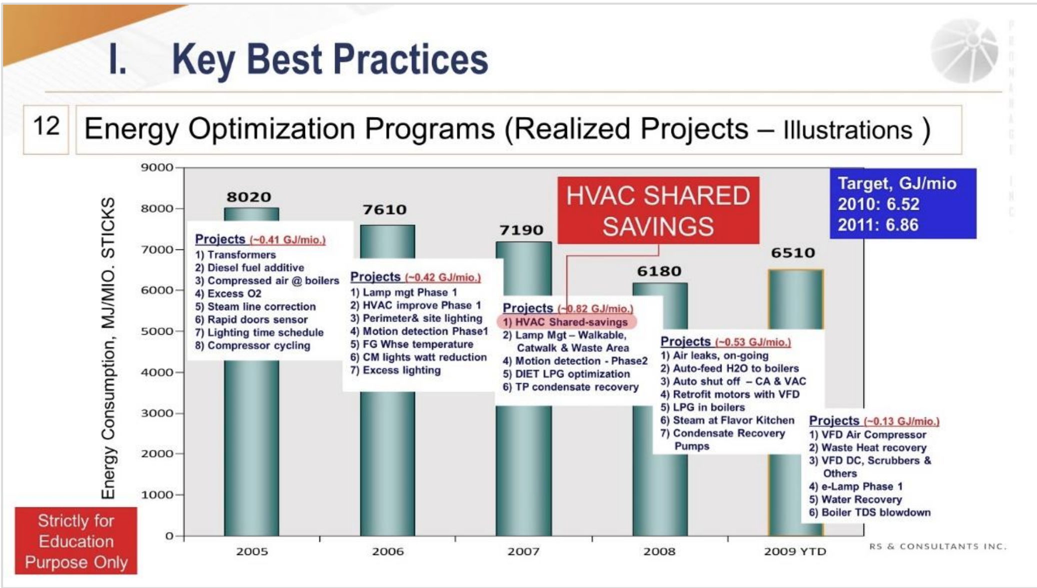
I. Key Best Practices
12
Energy Optimization Programs (Realized Projects – Illustrations)
Energy Consumption, MJ/MIO. STICKS
8020
7610
7190
6180
6510
HVAC SHARED SAVINGS
Target, GJ/mio
2010: 6.52
2011: 6.86
Projects (~0.41 GJ/mio.)
1) Transformers
2) Diesel fuel additive
3) Compressed air @ boilers
4) Excess O2
5) Steam line correction
6) Rapid doors sensor
7) Lighting time schedule
8) Compressor cycling
Projects (~0.42 GJ/mio.)
1) Lamp mgt Phase 1
2) HVAC improve Phase 1
3) Perimeter& site lighting
4) Motion detection Phase1
5) FG Whse temperature
6) CM lights watt reduction
7) Excess lighting
Projects (~0.82 GJ/mio.)
1) HVAC Shared-savings
2) Lamp Mgt – Walkable, Catwalk & Waste Area
4) Motion detection - Phase2
5) DIET LPG optimization
6) TP condensate recovery
Projects (~0.53 GJ/mio.)
1) Air leaks, on-going
2) Auto-feed H2O to boilers
3) Auto shut off – CA & VAC
4) Retrofit motors with VFD
5) LPG in boilers
6) Steam at Flavor Kitchen
7) Condensate Recovery Pumps
Projects (~0.13 GJ/mio.)
1) VFD Air Compressor
2) Waste Heat recovery
3) VFD DC, Scrubbers & Others
4) e-Lamp Phase 1
5) Water Recovery
6) Boiler TDS blowdown
2005
2006
2007
2008
2009 YTD
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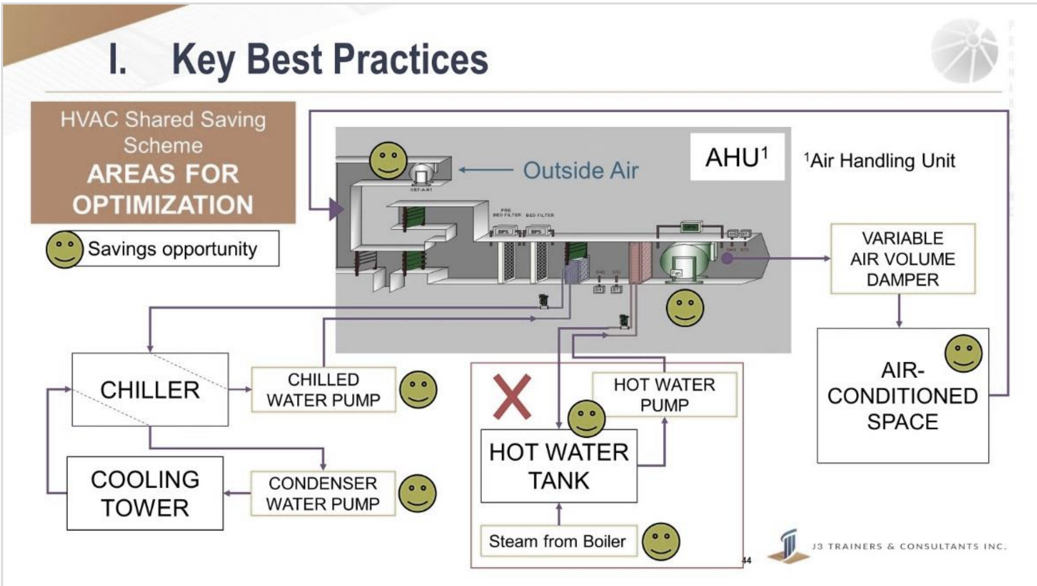
I. Key Best Practices
HVAC Shared Saving Scheme
AREAS FOR OPTIMIZATION
Savings opportunity
Outside Air
AHU1
1Air Handling Unit
VARIABLE AIR VOLUME DAMPER
AIR-CONDITIONED SPACE
CHILLER
CHILLED WATER PUMP
COOLING TOWER
CONDENSER WATER PUMP
HOT WATER PUMP
HOT WATER TANK
Steam from Boiler
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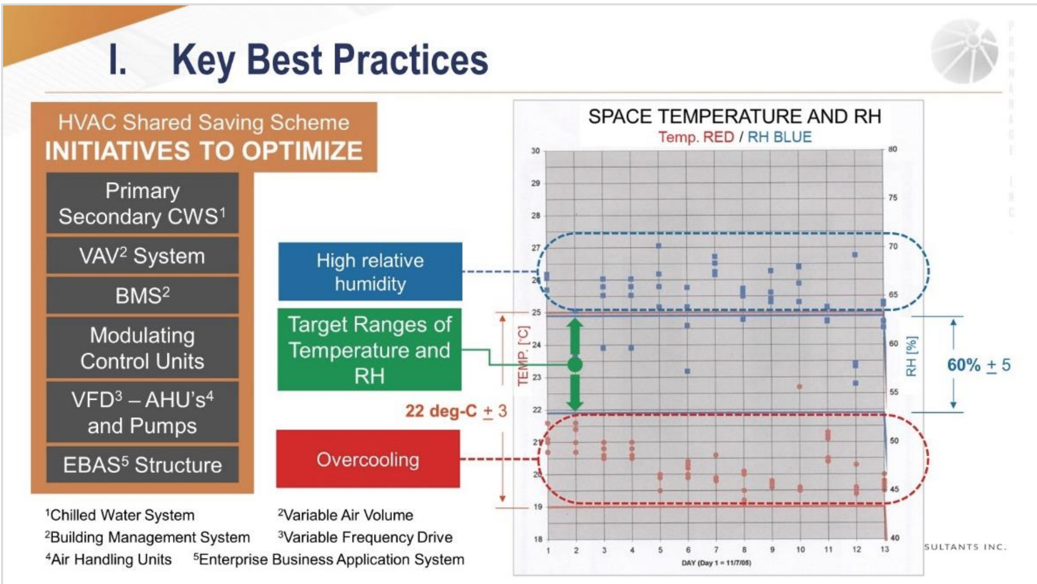
I. Key Best Practices
HVAC Shared Saving Scheme
INITIATIVES TO OPTIMIZE
Primary Secondary CWS1
VAV2 System
BMS2
Modulating Control Units
VFD3 – AHU's4 and Pumps
EBAS5 Structure
High relative humidity
Target Ranges of Temperature and RH
22 deg-C ± 3
Overcooling
SPACE TEMPERATURE AND RH
Temp. RED / RH BLUE
TEMP. [°C]
RH [%]
60% ± 5
DAY (Day 1 = 11/7/08)
1Chilled Water System
2Variable Air Volume
2Building Management System
3Variable Frequency Drive
4Air Handling Units
5Enterprise Business Application System
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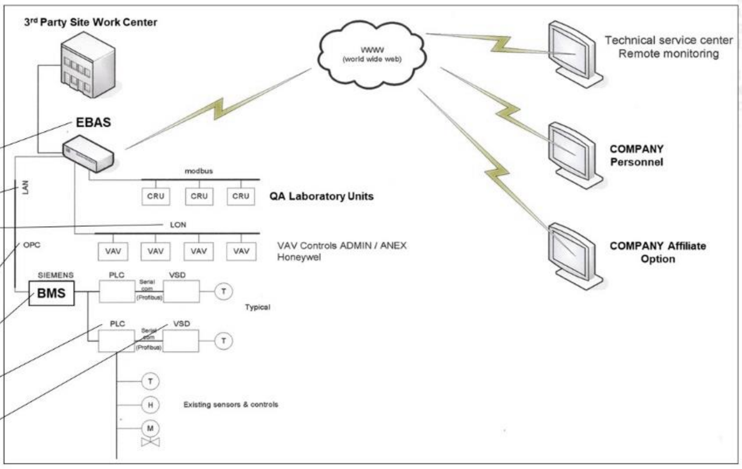
I. Key Best Practices

HVAC Shared Saving Scheme
INITIATIVES TO OPTIMIZE

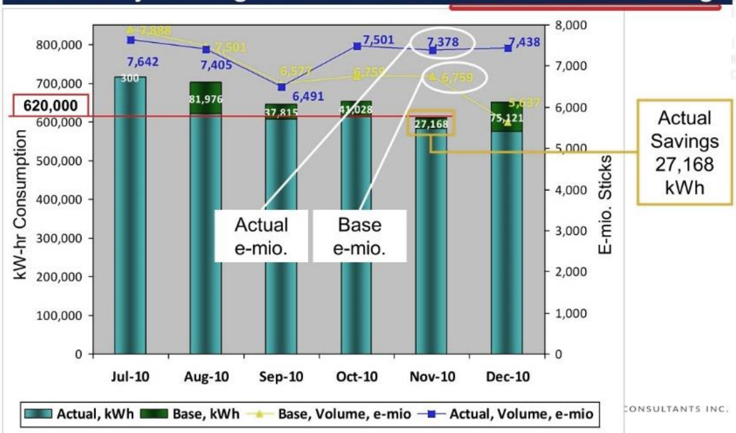
- Enterprise Business Application System
- Local Area Network
- Local Operating Network
- Open Platform Communication
- Building Management System
- Programmable Logic Controller
- Variable Speed Drive



I. Key Best Practices

HVAC Shared Saving Scheme
kWh and COST IMPACTS

Electricity Savings Translated to 70/30 Cost Sharing



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J. Chiller Efficiency and Performance

kW/Ton — the most common unit of measurement for chiller efficiency = electricity input (kW) / cooling capacity (RT)

Example:

Capacity (RT)	550
Rated Energy (kW)	282.7

kW/Ton = electricity input (kW) / cooling capacity (RT)
= 282.7kW / 550 RT
= 0.514 kW/RT

Lower Chiller kW/Ton ~ Higher Chiller Efficiency

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J. Chiller Efficiency and Performance

COP

Coefficient of Performance

- quantifies the efficiency of a system in transforming input energy into useful heating or cooling

= desired output (kW) / required input (kW)

Example:

Capacity (RT)	550
Rated Energy (kW)	282.7

Conversion:
1RT = 3.517 kW

COP = desired output (kW) / required input (kW)
= [550 ~~RT~~ x (3.517 ~~kW~~/1~~RT~~)] / (282.7 ~~kW~~)
= 6.84

Higher COP ~ Higher Chiller Efficiency

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J. Chiller Efficiency and Performance

EER

Energy Efficiency Ratio (EER)

- Higher EER rating means that an ACU will provide a lot of cooling effect for every Watt of energy you provide.

= cooling output (in BTU/h) /electricity input (W)

Example:

Capacity (RT)	**550**
Rated Energy (kW)	282.7

Conversion:
1RT = 12,000 BTU/h

EER = cooling output (in BTU/h) /electricity input (W)
= [550 ~~RT~~ x (12,000 BTU/h/1~~RT~~)] / (282.7 ~~kW~~ x 1000W/1~~kW~~)
= 23.346 BTU/h /W

The higher EER, the better

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J. Chiller Efficiency and Performance – **Chiller IPLV / NPLV Calculation**

IPLV – Integrated Part Load Value

The AHRI[1] and industry-standard way of measuring the overall average efficiency of a hydronic (chiller) cooling system

Similar concept to SEER[2], where part-load performance is measured and rated so that customers can have a way to do an apples-to-apples comparison of real-world operating efficiency between various brands and models

IPLV band its companion NPLV[2] are both specified in AHRI 550/590

[1]Airconditioning, Heating and Refrigeration Institute [2]Seasonal Energy Efficiency Ratio
[3]No-standard Part Load Value

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J. Chiller Efficiency and Performance – AHRI 550/590-1998

IPLV/NPLV Equation And Rating Conditions From ARI Standard 550/590–1998

Expression Of Chiller Efficiency	Equation
Coefficient Of Performance–COP, W/W, or Energy Efficiency Ratio–EER, Btu/h/W	IPLV or NPLV = 0.01A + 0.42B + 0.45C + 0.12D
Power Per Ton, kW/ton	$\text{IPLV or NPLV} = \dfrac{1}{\dfrac{0.01}{A} + \dfrac{0.42}{B} + \dfrac{0.45}{C} + \dfrac{0.12}{D}}$

Weighting Of Part-Load Points

Part-Load Point, %	Weighting, % 1992 Standard	Weighting, % 1998 Standard
100	17	1
75	39	42
50	33	45
25	11	12

A	COP or EER @100% Load (1% of the time the unit needs to run at around 100% capacity)
B	COP or EER @75% Load (42% of the time the unit needs to run at around 75% capacity)
C	COP or EER @50% Load (45% of the time the unit needs to run at around 50% capacity)
D	COP or EER @25% Load (12% of the time the unit needs to run at around 25% capacity)

Values to be referred from User Condition (Table) – AHRI Std

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https://www.chiltrix.com/documents/IPLV-NPLV-Explained-Comparison.pdf
https://www.trane.com/content/dam/Trane/Commercial/global/products-systems/education-training/engineers-newsletters/standards-codes/en_28-01.pdf

J. Chiller Efficiency and Performance – Chiller IPLV/NPLV Calculation

Example:

User Condition NPLV: 0.64

No.	Percent (%)	Cooling capacity (US.RT)	Input power (kW)	Performance coefficient (kW/Ton)	
1	100	600.1	339.6	0.57	A
2	90	540.1	312.1	0.58	
3	80	480.1	281.7	0.59	
4	75	450.1	265.9	0.59	B
5	70	420.1	249.8	0.59	
6	60	360.1	216.2	0.6	
7	50	300.1	196.9	0.66	C
8	40	240	164.6	0.69	
9	30	180	133.1	0.74	
10	25	150	115.4	0.77	D
11	12.5	75	65.7	0.88	

Formula:

Weighting of Part-Load Points

$$\text{IPLV OR NPLV} = \frac{1}{\dfrac{0.01}{A} + \dfrac{0.42}{B} + \dfrac{0.45}{C} + \dfrac{0.12}{D}}$$

$$= \frac{1}{\dfrac{0.01}{0.57} + \dfrac{0.42}{0.59} + \dfrac{0.45}{0.66} + \dfrac{0.12}{0.77}}$$

= 0.638 kW/Ton

Source: https://aircondlounge.com/chiller-efficiency-calculation-kw-ton-cop-eer-iplv-nplv/

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PRACTICE

What is the primary purpose of an HVAC system in a building?

a. Lighting
b. Temperature control
c. Security
d. Sound insulation

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PRACTICE

In the context of HVAC, what does VAV stand for?

a. Variable Air Volume
b. Very Airy Ventilation
c. Viscous Air Velocity
d. Ventilation Adjustment Valve

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PRACTICE

Which component of an HVAC system is responsible for compressing the refrigerant and raising its temperature and pressure?

a. Evaporator
b. Condenser
c. Compressor
d. Expansion Valve

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PRACTICE

What is the purpose of heat recovery in an HVAC system?

a. To cool the air
b. To reduce humidity
c. To capture and reuse waste heat
d. To improve air quality

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PRACTICE

Which HVAC system feature allows for adjusting the flow rate of chilled water based on the actual cooling demand?

a. Variable Speed Drives (VSD)
b. Demand-Controlled Ventilation (DCV)
c. Programmable Thermostats
d. Heat Recovery Ventilation (HRV)

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KNOWLEDGE REVIEW

A heating system uses water to transport heat throughout a building. The water is heated from 10°C to 60°C, and the system needs to deliver a heating capacity of 30 kW. Calculate the mass flow rate of the water. The specific heat capacity of water is approximately 4,186 J/kg·°C.

Use the formula: $Q = m \; x \; C_p \; x \; \Delta T$

$$\boldsymbol{m} = \frac{\boldsymbol{Q}}{(\boldsymbol{Cp \; x} \; \Delta T\,)}$$

$$= \frac{\mathbf{30{,}000}\,\frac{J}{s}}{\left(\mathbf{4{,}186}\,\frac{J}{kg \cdot {}^{\circ}\mathrm{C}}\right) \boldsymbol{x} \; (\mathbf{60 - 10})}$$

$$= \mathbf{0.143}\,\frac{\boldsymbol{kg}}{\boldsymbol{s}}$$

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KNOWLEDGE REVIEW

An industrial process requires cooling of a fluid from 80°C to 30°C. The process operates continuously with a fluid mass flow rate of 0.5 kg/s. The specific heat capacity of the fluid is 3,800 J/kg·°C. Calculate the cooling load required by this process.

Use the formula: $Q = m \; x \; C_p \; x \; \Delta T$

$$Q = \left(\mathbf{0.5}\,\frac{\boldsymbol{kg}}{\boldsymbol{s}}\right) \boldsymbol{x} \left(\mathbf{3{,}800}\;\frac{\boldsymbol{J}}{\boldsymbol{kg} \cdot {}^{\circ}\mathrm{C}}\right) \boldsymbol{x} \; (80^{\circ}\mathrm{C} - 30^{\circ}\mathrm{C})$$

$$= 95{,}000W$$

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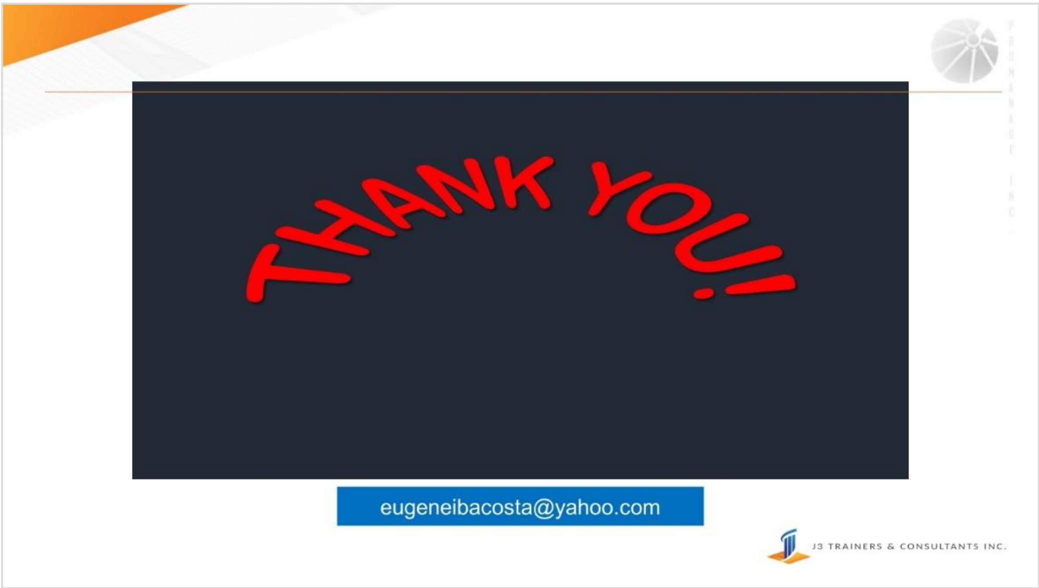
THANK YOU!
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