HVAC System Options

for

Ashland Public Safety Building
Ashland, MA

GARCIA • GALUSKA • DESOUSA
Consulting Engineers Inc.

Overview

1. Goal of Economic Analysis

2. HVAC System Option Overview

   – Baseline: Split System Variable Volume HW Air-Handling Units (IECC 2018 Baseline)

   – Option 1 : VAV System w/ High-Efficiency Boilers

   – Option 2 : CHW Induction Unit System with DOAS

   – Option 3 : VRF System with DOAS

   – Option 4: Geothermal (Ground Source) Option

3. Economic Analysis Methodology

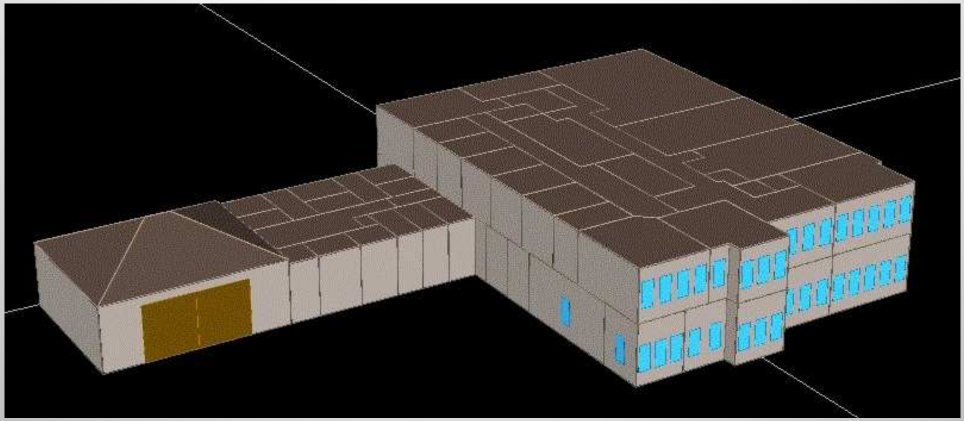
4. Questions and Discussion

Goal of LifeCycle Economic Analysis

The goal of the mechanical lifecycle engineering economic analysis is to assess the performance of various mechanical systems in comparison to a baseline mechanical system.

Each option is compared to the baseline system to determine the lowest combined savings over a 30 year cycle to determine the most advantageous system considering electrical costs, gas costs, maintenance costs, and initial construction costs.

By comparison of each option to the baseline system, the option with the greatest total life-cycle savings is generally recommended. To further enhance controllability and overall system performance, additional measures should be considered that will enhance year round temperature control and comfort at a possible marginal increase in capital cost.

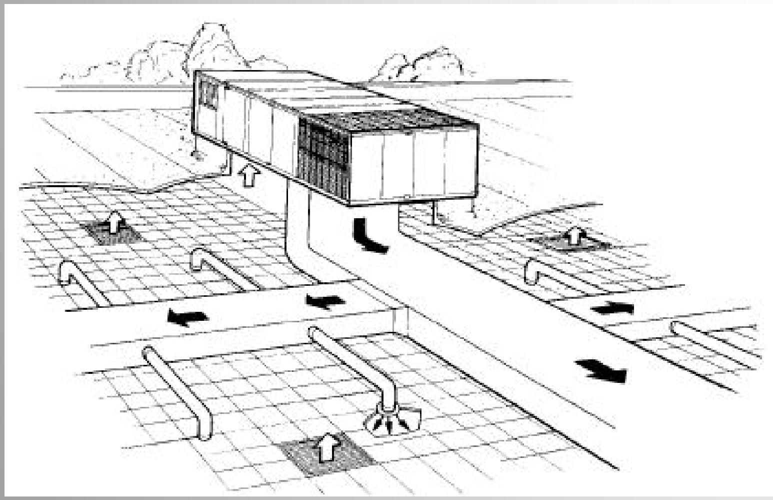


Baseline – Split System HW/ DX Variable Volume Air Handling Units (IECC 2018 Baseline)

Pros:

•Chiller plant and piping distribution systems not required

•Reduced automatic temperature controls installed costs resulting from reduced control components



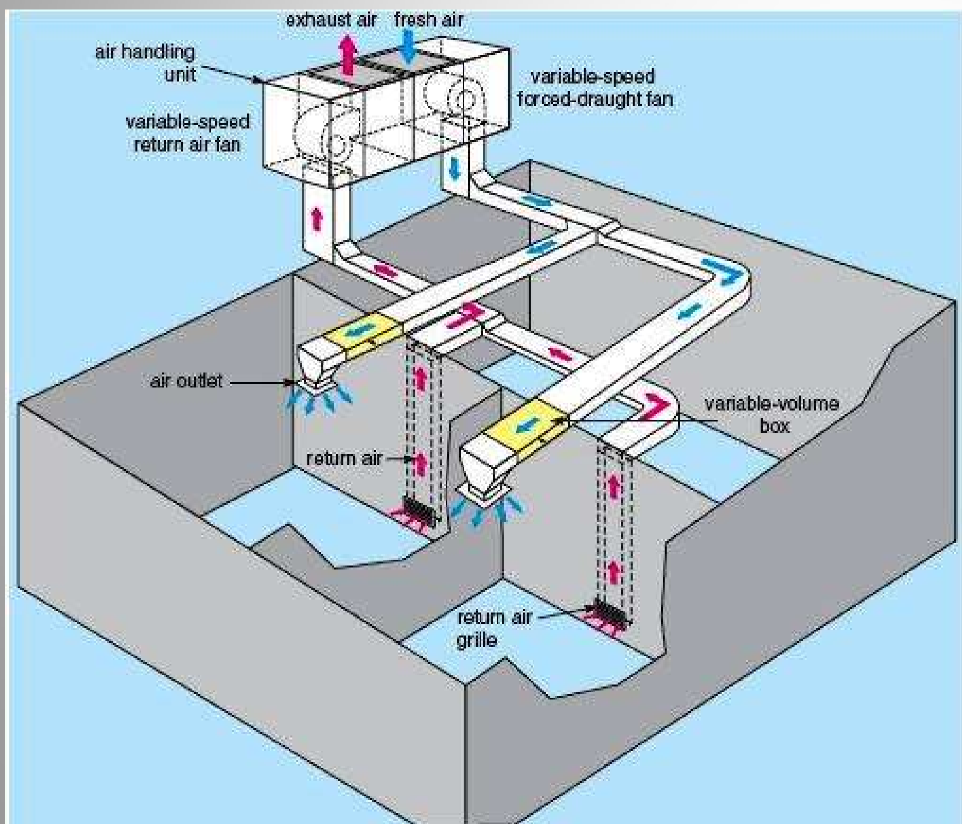
Cons:

- Moderate noise levels
- Reduced temperature control if several rooms are served by the same VAV unit
- Reduced indoor air quality as a result of being a mixed-air system
- Maintenance of equipment is in occupied area
- Higher energy consumption when compared to the design options
- Overall ductwork costs are greater due to the larger supply and return ductwork systems providing mixed-air rather than ventilation only

Option 1 – HW/CHW VAV System

Pros:

- Moderate overall installed costs
- Low maintenance; no condensate drains, fans, or filters at terminal units
- Reduced automatic temperature controls installed costs resulting from reduced control components



Cons:

- Moderate noise levels
- Reduced temperature control if several rooms are served by the same VAV unit
- Reduced indoor air quality as a result of being a mixed-air system
- Maintenance of equipment is in occupied area
- Higher energy consumption due to increased fan energy
- Higher energy consumption as summertime use of hot water system is required for hot water reheats of VAV boxes
- Overall ductwork costs are greater due to the larger supply and return ductwork systems providing mixed-air rather than ventilation only

Option 2 – Chilled Beam Induction Unit System w/ DOAS

Pros:

- High energy efficiency
- Low noise levels
- Flexibility of installation
- Moderate first cost
- Very low maintenance, no fans or filters at units
- Moderate overall installed costs
- Excellent humidity control
- Higher amounts of outside air required to meet capacity of units in smaller zone areas; resulting in improved indoor air quality
- No electrical requirements for terminal units
- No floor space required for equipment
- Each unit can provide individual control

Cons:

- Requires increased coordination with "ceiling" system. (e.g. additional piping, HW, CHW & condensate piping)
- Requires additional ventilation air in some cases
- Condensate drain maintenance for terminal units

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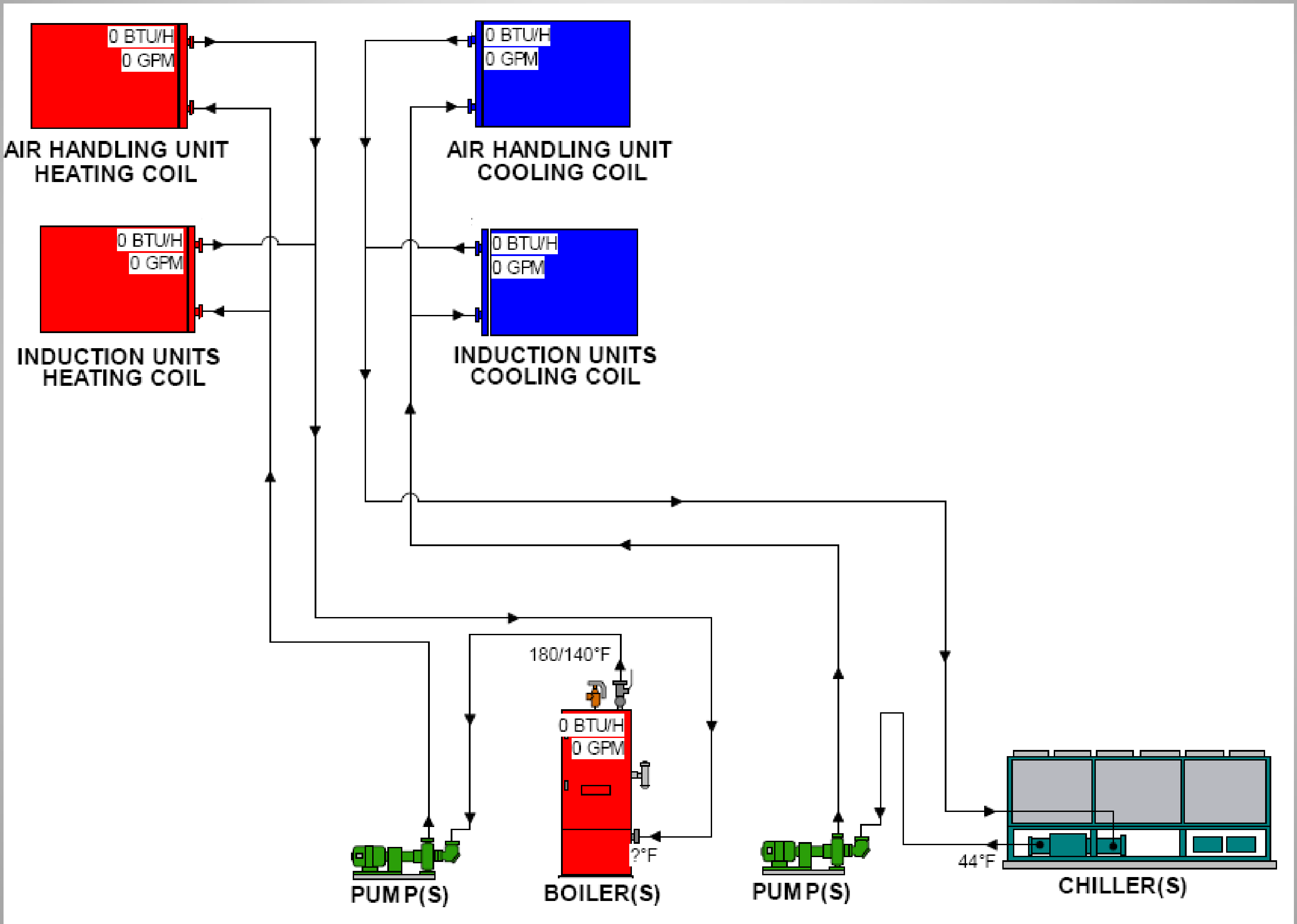
Option 2 – Chilled Beam Induction Unit System (Piping Diagram)



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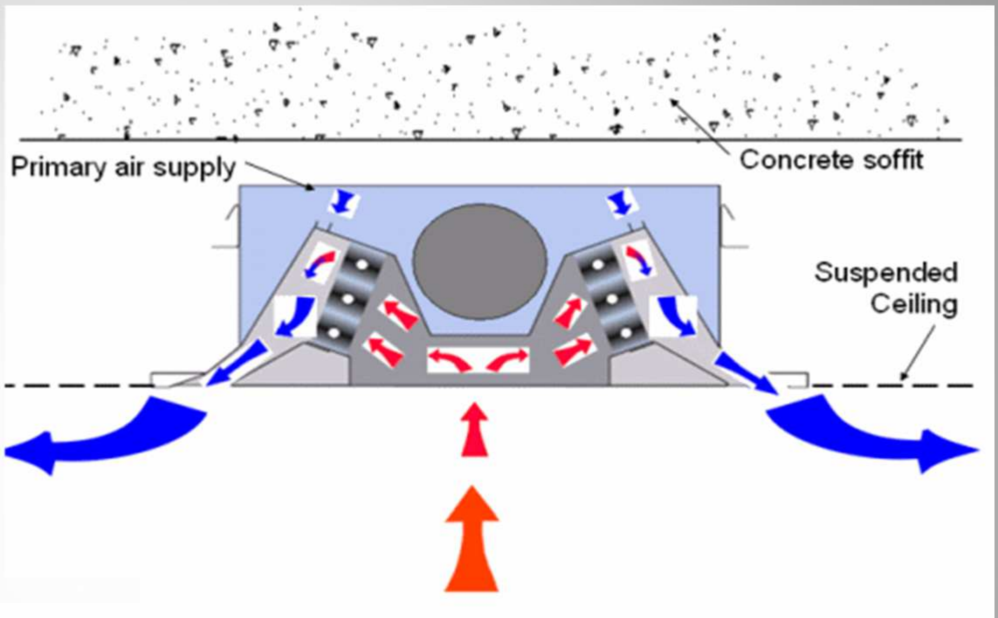
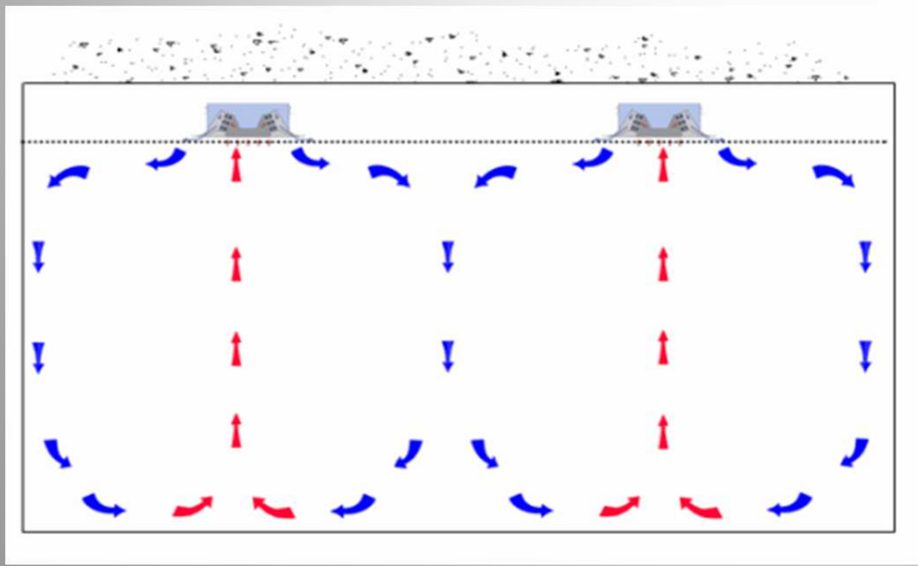
Option 2 –
How Chilled Beam/Induction Units Work

- Primary Air supplied to plenum and discharges through nozzles

- Room air is induced through the heating/cooling coils

- Mixture of Primary and Room air is delivered to room through diffuser slots.





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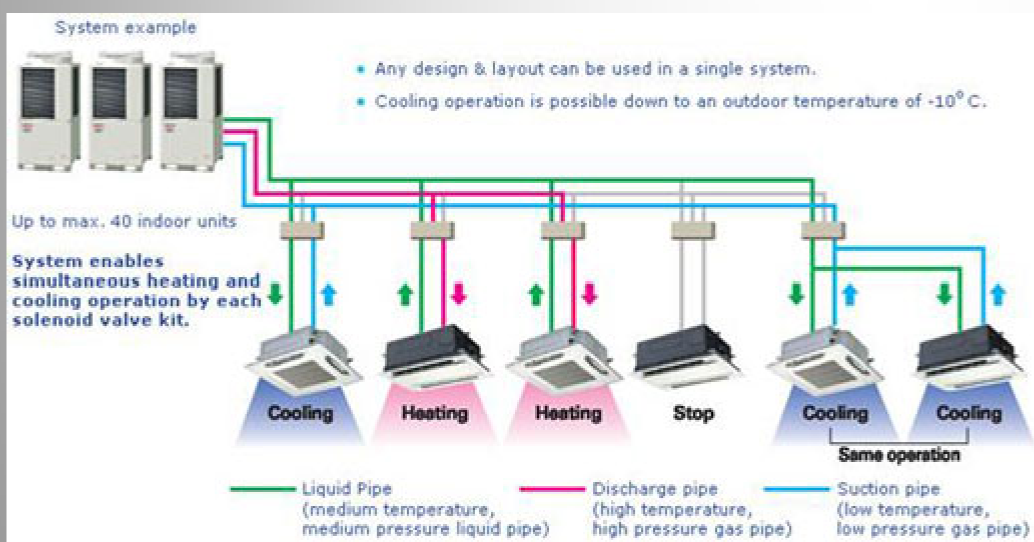
Option 3 – Variable Flow Refrigerant (VRF) System w/ DOAS

Pros:

- Low piping installed costs due to refrigerant piping system only
- Moderate overall installed costs
- Chiller plant and distribution systems not required
- Reduced boiler plant size
- Single cabinet can be utilized for both heating and cooling applications
- Smaller central ventilation ductwork as only the code required ventilation air is provided to meet occupancy load
- **Can be Air Source (Option 3) or Ground Source (Option 4)**

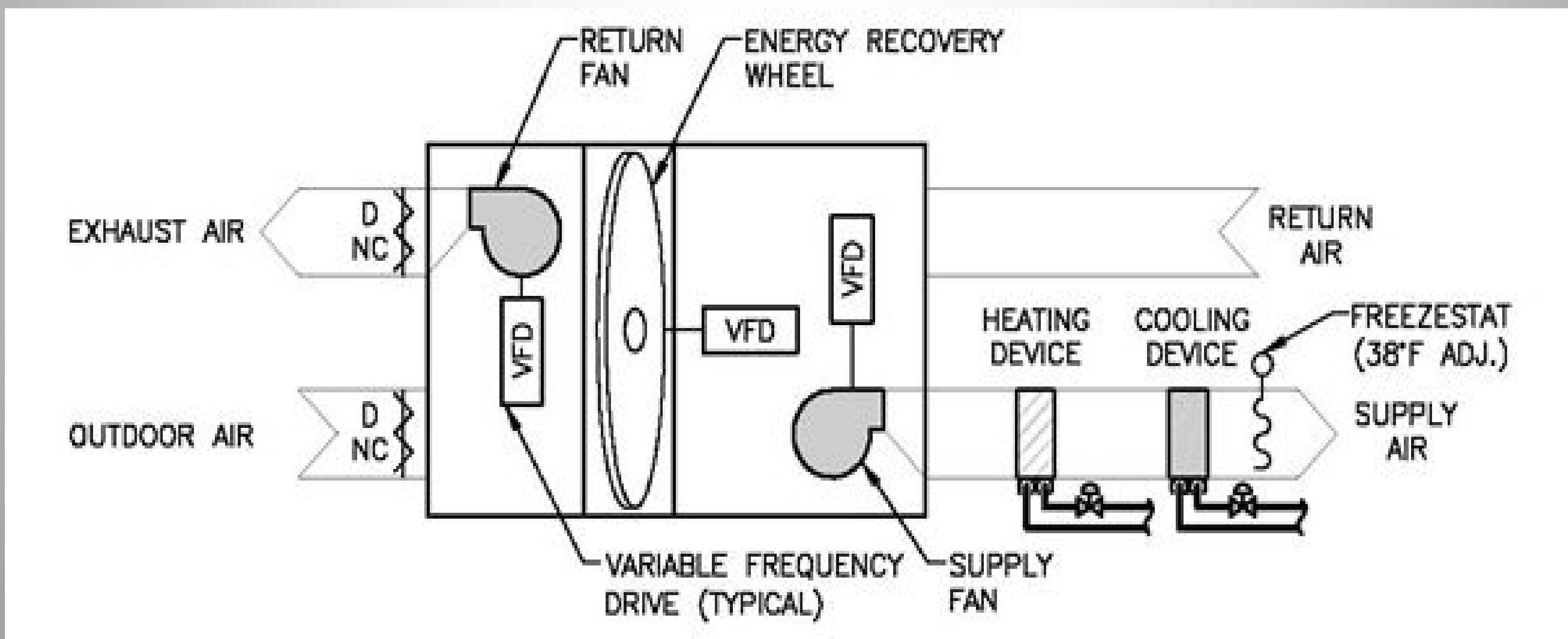


Cons:

- Individual fan motors in space
- Higher noise levels
- Quarterly filter changes per unit
- More complex automatic temperature controls
- Higher automatic temperature controls installed costs on a per unit basis due to amount of control devices required
- Condensate drain maintenance for terminal units
- Maintenance of equipment is in occupied area
- Higher energy consumption due to increased electric heating

Dedicated Outside Air Handling System

- **Typical to System Options 2, 3 & 4**
- **Increases Energy Efficiency due to:**
  - **Energy Recovery**
  - **Sizing Equipment for Specific Duty (AHU for Latent Cooling and Terminal Units for Sensible Cooling)**



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HVAC Plant and
Supplemental Systems and Equipment

<u>Boiler Plant (Options 1, 2 & 3)</u>

- High efficiency (90%+) gas-fired condensing boilers
- Boiler temperature reset controls
- Variable speed pumps with VFD's

<u>Chiller Plant (Option 1 & 2 Only)</u>

- High efficiency air-cooled chiller
- Chilled water temperature reset controls
- Variable speed pumps with VFD's

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Geothermal (Option 4)- Closed Loop Geothermal Field

Vertical closed loop wells are used to provide ground source condenser water to heat recovery heat pump chiller plant, which is used to provide hot water heating and chilled water cooling

Pros:

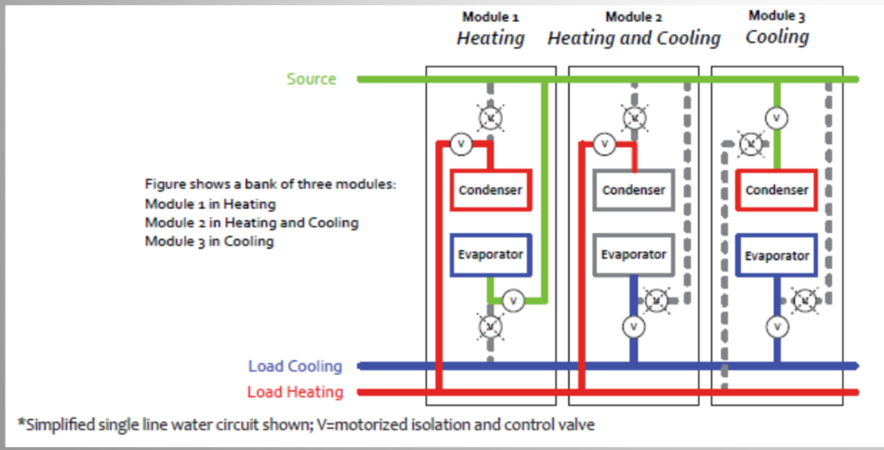
- Lower maintenance costs
- High energy efficiency & Lower operating costs
- Lower replacement costs as pumps located within building and no Cooling Tower or Dry Cooler is required

Cons:

- Test wells required
- Increased permitting
- Higher first cost

High-Efficiency Water Source Heat Pump Chillers w/ Heat Recovery (Option 4 – Geothermal (GroundSource) Wells for Options 1 or 2)

Modular Heat Recovery Heat Pump Chillers

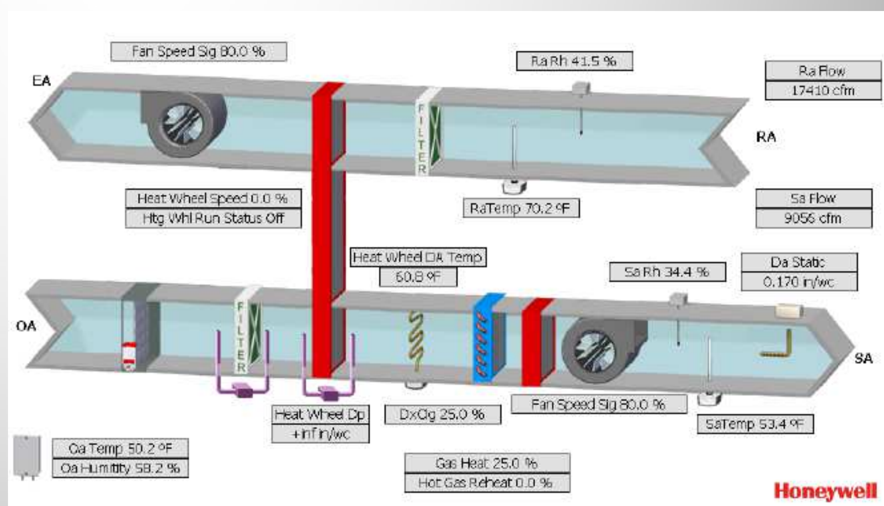


BENEFITS:

- High-efficiency
- Modular design provides level of redundancy & individual module control
- Heat recovery provides reheat during cooling season
- Maneuverable – All modules fit through 36” door and have low center of gravity with base cutouts for pallet jacks/forklifts
- Durability & Reliability
- Service friendly with easy access to all major components
- Fossil Fuel Free - Zero combustion design

Building Automation and Energy Management System

- System (Zone) Scheduling
- Occupied-Unoccupied Control
- Night Setback Operation
- Lighting Control System Integration
- Increased Energy Savings
- Integrate with Preventative Maintenance Scheduling



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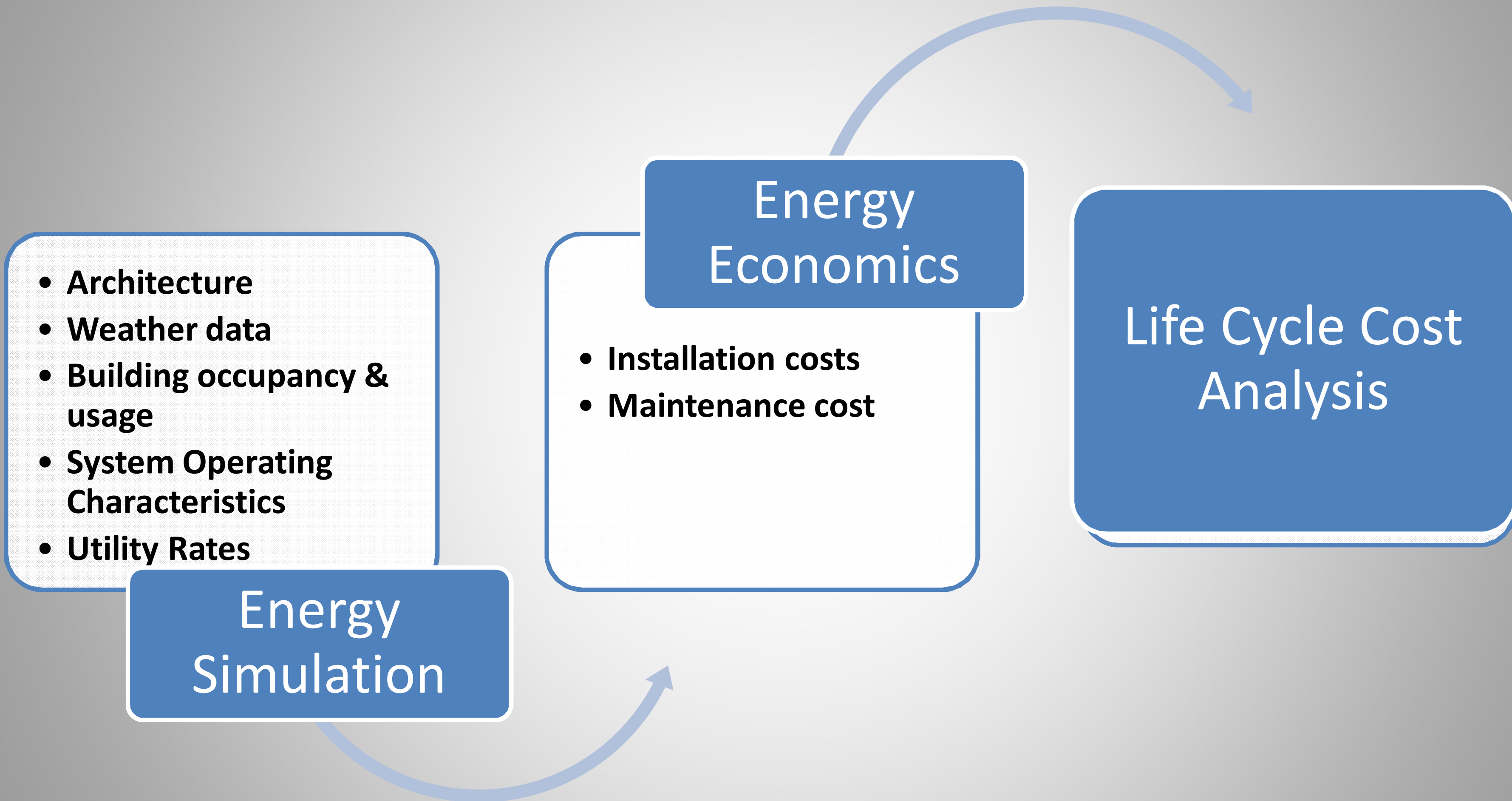
Energy Economics Methodology



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Energy Model Analysis Methodology

- Computer Simulation of Building Energy Usage using Department of Energy (DOE-2)/eQuest.
- Model consists of project specific:
  - Architectural features (geometry, orientation, envelope)
  - Lighting Power Density
  - Local Weather Data
  - Occupancy, Lighting, Equipment Schedules
  - HVAC System Data (specific to each system option)
  - Regional or Actual Owner Utility Rates
- Computer calculation of HVAC System economics utilizing NIST BLCC 5.
- Calculation factors:
  - HVAC System and Maintenance Cost Estimates
    - Prepared in house using recent project cost data and industry standard estimating references.
  - Standard Industry Discount, Inflation, and Interest Rates

Summary of Results

Ashland Public Safety - Mechanical System Payback Summary

Baseline / Option	System	Gross Capital Investment*	Annual Elec. Cons. (kWh)	Annual Gas Cons. (MBTU)	Annual Electric Cost	Annual Gas Cost	Combined Utility Cost	Annual Utility $/s.f.	Annual kBTU/s.f. (EUI)	Annual Maint. Cost	Combined Annual Expense	Combined Expense Savings**	Total Life-Cycle Savings***	Discounted Payback (Years)****
Baseline														
-	1. Hot water coil heating/dx cooling VAV AHU system with energy recovery wheel & air-cooled condensing unit serving terminal VAV boxes with hot water reheat coils 2. Standard efficiency gas-fired boiler plant	$2,419,543	291,650	4,139.6	$40,832	$48,433	$89,265	$2.26	129.99	$23,625	$112,890	$0	-	-
Option														
1	1. Hot water coil heating/chilled water coil cooling VAV AHU system with energy recovery wheels serving terminal VAV boxes with hot water reheat coils 2. High efficiency gas-fired condensing boiler plant 3. High efficiency air-cooled chiller plant	$2,488,543	293,210	3,473.8	$41,049	$40,644	$81,693	$2.07	113.27	$23,625	$105,318	$7,572	$163,050	9
2	1. Four-pipe chilled/hot water coil induction units 2. Hot water coil heating/chilled water coil cooling 100% O.A. VAV ventilating unit with energy recovery wheels 3. High efficiency gas-fired condensing boiler plant 4. High efficiency air-cooled chiller plant	$2,458,413	280,270	3,495.8	$39,238	$40,900	$80,138	$2.03	112.71	$23,300	$103,438	$9,452	$247,798	4
3	1. Variable refrigerant flow (VRF) terminal evaporator units with air-cooled condensing units 2. Hot water coil heating/dx cooling 100% O.A. VAV ventilating unit with energy recovery wheel & air-cooled condensing unit 3. High efficiency gas-fired condensing boiler plant	$2,419,255	306,310	3,204.1	$42,883	$36,527	$79,410	$2.01	107.58	$31,700	$111,110	$1,780	$53,216	Instant*****
4	1. Four-pipe chilled/hot water coil induction units 2. Hot water coil heating/chilled water coil cooling 100% O.A. VAV ventilating unit with energy recovery wheels 3. Geothermal wells with high efficiency water-to-water source heat pump chiller/heating plant	$3,362,600	538,300	0.0	$75,362	$0	$75,362	$1.91	46.50	$25,275	$100,637	$12,253	-$526,779	Not Reached*****

Thank You

Questions and Discussions