NEW TECHNOLOGIES IN ENERGY MANAGEMENT

USING ASHRAE CODES FOR INNOVATIVE DESIGN

HVAC INDUSTRY DESIGN STANDARDS
CONVENTIONAL VS. OPTIMUM

"Rule of Thumb"	**Conventional**	**Optimum**
Cooling – SF/Ton	400 SF	800 SF
Heating – BTU/SF	30 BTU	15 BTU
Boiler LHWT – F	180F	100-120F
Ventilation – CFM/Person	15-20 CFM	0-5 CFM
Filter – Efficiency/MERV	MERV 9-10	Air Cleaners
ERU Required	Gyms- Cafés	Air Cleaners
ATC Valve Location	Return	ECM Motors
DCV – CO2 PPM	1,200 PPM	2,800 PPM

CLASSROOM VENTILATION REQUIREMENTS
CONVENTIONAL VENTILATION RATE METHOD (VRM)
REFERENCE IS ASHRAE 62.1

- 1,000 Square Foot Classroom
  - 30 People
- Using Conventional ASHRAE 62.1 VRM Method
  - From Table 6.1
  - 15 CFM per Person
  - 450 CFM total Outside Air
- Conventional Unit Ventilator CFM
  - 1,200 CFM of Supply Air
- 37.5% of CFM is Outside Air
  - 26% of Peak Cooling Tons
  - 55% of Peak Heating MBH

CLASSROOM VENTILATION REQUIREMENTS
OPTIMUM INDOOR AIR QUALITY METHOD (IAQ)
REFERENCE IS STILL ASHRAE 62.1

- 1,000 Square Foot Classroom
  - 30 People
- Using ASHRAE 62.1, Chapter 6.3 - IAQ Method
  - Engineer must use Mass Flow Equations to determine the amount of each "Contaminant of Concern":
    - Ammonia
    - Methane
    - Formaldehyde
    - Carbon monoxide
    - Radon
    - Volatile Organic Compounds

CLASSROOM VENTILATION REQUIREMENTS
OPTIMUM INDOOR AIR QUALITY METHOD (IAQ)

6.3 Indoor Air Quality (IAQ) Procedure. Breathing zone outdoor airflow (V_{bz}) and/or system outdoor air intake flow (V_{ot}) shall be determined in accordance with Sections 6.3.1 through 6.3.5.

6.3.1 Contaminant Sources. Contaminants or mixtures of concern, for purposes of the design, shall be identified. For each contaminant or mixture of concern, indoor sources (occupants and materials) and outdoor sources shall be identified, and the emission rate for each contaminant of concern from each source shall be determined.

Note: Informative Appendix B provides information for some potential contaminants of concern.

CLASSROOM VENTILATION REQUIREMENTS
OPTIMUM INDOOR AIR QUALITY METHOD (IAQ)

- Using **Optimum** IAQ Method with Air Cleaners
  - 5 CFM per Person
  - 150 CFM per Classroom
  - 67% reduction in Ventilation requirements
- Bi-Polar Ionization is one method:
  - Generates Ions
    - Ions break down Contaminants of Concern into their basic elements
  - Example:
    - Ions break Ammonia (NH4) into Nitrogen, Hydrogen and Water Vapor

OPTIMUM DEMAND CONTROL VENTILATION

- Allowable PPM of CO_2 with IAQ Method and Air Cleaners
  - **Optimum-** 2,800 PPM of CO_2
  - Conventional- 1,200 ppm
- Outside Air Dampers
  - **Optimum-** OA Damper Normally Closed
  - Conventional- minimum position of 33% in Classrooms
- This method can also be applied to ERUs and Air Handlers

ENERGY RECOVERY UNITS (ERU)
ASHRAE STANDARD 90.1
MINIMUM ENERGY REQUIREMENTS

- Conventional interpretation of Standard 90.1 is that Energy Recovery Units are required for:
  - Gyms, Cafeterias, other large "Areas of Assembly"
- ERUs have better paybacks with:
  - High hours of operation
  - Large amounts of Outside Air Ventilation
- ERUs
  - Add cost and complexity
  - Add maintenance requirements
  - Add at least two (2) fans per unit
  - Add weight to roof

ENERGY RECOVERY UNITS (ERU)

TABLE 6.5.6.1-1 Exhaust Air Energy Recovery Requirements for Ventilation Systems Operating Less than 8000 Hours per Year

Zone	% Outdoor Air at Full Design Airflow Rate							
	≥10% and <20%	≥20% and <30%	≥30% and < 40%	≥40% and < 50%	≥50% and < 60%	≥60% and < 70%	≥70% and < 80%	≥80%
	Design Supply Fan Airflow Rate, cfm							
3B, 3C, 4B, 4C, 5B	NR	NR	NR	NR	NR	NR	NR	NR
1B, 2B,5C	NR	NR	NR	NR	≥26000	≥12000	≥5000	≥4000
6B	≥28,000	≥26,500	≥11000	≥5500	≥4500	≥3500	≥2500	≥1500
1A, 2A, 3A, 4A, 5A, 6A	≥26,000	≥16,000	≥5500	≥4500	≥3500	≥2000	≥1000	>0
7,8	≥4500	≥4000	≥2500	≥1000	>0	>0	>0	>0

- **Optimum** Method shows that where:
  - Ventilation requirements are less than 20% of the total Design Supply Airflow, and units operate less than 8,000 hours per year, then…
    - **NO ERUs ARE REQUIRED**

IAQ METHOD WITH AIR CLEANERS
BENEFITS OF THIS OPTIMUM METHOD

- 67% reduction in Maximum Ventilation Requirements
- 30% reduction in the size of Chiller
- 50% reduction in the size of Boiler
- 15% reduction in building kW demand
- 35% reduction in building kWh
- 50% reduction NG MCF
- Improved indoor air quality

DESIGN OUTSIDE AIR AMBIENT

- **Conventional**:
  - Summer Dry Bulb - 95F
  - Summer Wet Bulb - 78F
- **Optimum: ASHRAE 90.1**

TABLE D-1 U.S. and U.S. Territory Climatic Data *(Continued)*

State/City	Latitude	Longitude	Elev., ft	HDD65	CDD50	Heating Design Temperature	Cooling Design Temperature		Number of Hours 8 a.m.–4 p.m.
							Dry-Bulb	Wet-Bulb	
						99.6%	1.0%	1.0%	$55 < T_{db} < 69$
(Pennsylvania cont.)									
Johnstown	40.33 N	78.92 W	1214	5649	3028	NA	NA	NA	NA
Lancaster	40.05 N	76.28 W	270	5584	3079	NA	NA	NA	NA
Meadville	41.63 N	80.17 W	1065	6934	2209	NA	NA	NA	NA
New Castle	41.02 N	80.37 W	825	6542	2502	NA	NA	NA	NA
Philadelphia WSCMO AP	39.88 N	75.23 W	10	4954	3623	11	89	74	646

DESIGN OUTSIDE AIR AMBIENT

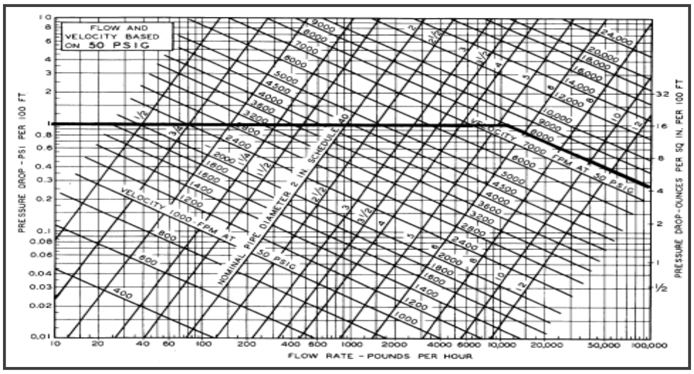
ASHRAE 90.1 – TABLE D-1

OPTIMUM METHOD

- 89/74 Summer
  - Chiller Smaller
  - Cooling Tower Smaller
  - CT Fan Motor – Less HP
  - CWP – Smaller and Less HP

ASHRAE STANDARD 90.1
MINIMUM ENERGY REQUIREMENTS
PIPE SIZING

- Conventional Chart



ASHRAE STANDARD 90.1
MINIMUM ENERGY REQUIREMENTS
PIPE SIZING: CONSTANT VS. VARIABLE FLOW

TABLE 6.5.4.6 Piping System Design Maximum Flow Rate in GPM

Operating Hours/Year	≤2000 Hours/Year		>2000 and ≤4400 Hours/Year		>4400 Hours/Year	
Nominal Pipe Size, in.	Other	Variable Flow/ Variable Speed	Other	Variable Flow/ Variable Speed	Other	Variable Flow/ Variable Speed
2 1/2	120	180	85	130	68	110
3	180	270	140	210	110	170
4	350	530	260	400	210	320
5	410	620	310	470	250	370
6	740	1100	570	860	440	680
8	1200	1800	900	1400	700	1100
10	1800	2700	1300	2000	1000	1600
12	2500	3800	1900	2900	1500	2300
Maximum velocity for pipes over 14–24 in. in size	8.5 ft/s	13.0 ft/s	6.5 ft/s	9.5 ft/s	5.0 ft/s	7.5 ft/s

CONSTANT VS. VARIABLE FLOW
CHILLERS AND BOILERS

- Chiller manufacturers for years preached:
  - Constant flow through chilled water barrel
  - Still say constant flow through condenser
  - No less than 80F ECWT
- Boilers
  - Constant HW flow at all times
  - 180F LHWT
  - No less than 140F RHWT

CONSTANT VS. VARIABLE FLOW
CHILLERS AND BOILERS

- Conventional Method
  - Constant flow pumps
  - Triple Duty Valves
  - Circuit Setters
  - Bypass Lines
  - 3-Way Valves
  - Primary/Secondary Pumping
  - Primary/Secondary/Tertiary Pumping

CONSTANT VS. VARIABLE FLOW
CHILLERS AND BOILERS

- Optimum Method
  - Variable Speed Everything!
  - Primary Variable Speed Pumping Only
  - Half Speed = 87% Energy Savings
  - No balancing Valves
  - No Bypass Lines
  - Fewer Control Devices
  - Simpler SOO

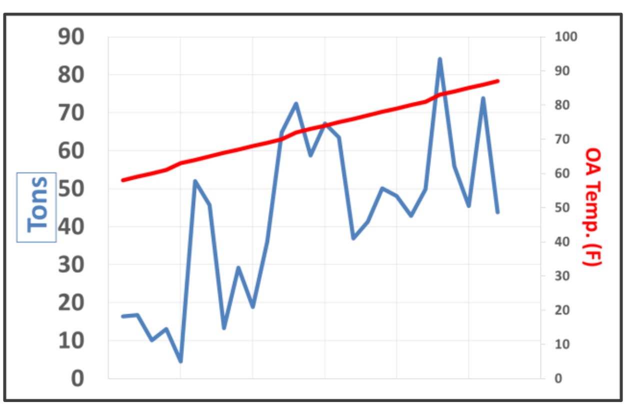
TERMINAL UNIT CONTROL

- Conventional
  - Constant Speed Fan-Runs During Occupied Hours
  - Water Circuit Setter
  - ATC Valve Modulates to Maintain Space
- Optimum
  - VFDs and ECM Motors-Vary Fan Speed to Room Temp Setpoint
  - No Water Circuit Setters
  - Minimize ATC Valve Control to Maintain Leaving Air Temp

HVAC INDUSTRY DESIGN STANDARDS
EVOLVING BUILDINGS NOW USE OPTIMUM SOLUTIONS

"Rule of Thumb"	Optimum
Cooling – SF/Ton	800 SF
Heating – BTU/SF	15 BTU
Boiler LHWT – F	100-120F
Ventilation – CFM/Person	0-5 CFM
Filter – Efficiency/MERV	Air Cleaners
ERU Required	Air Cleaners
ATC Valve Location	ECM Motors
DCV – CO2 PPM	2,800 PPM

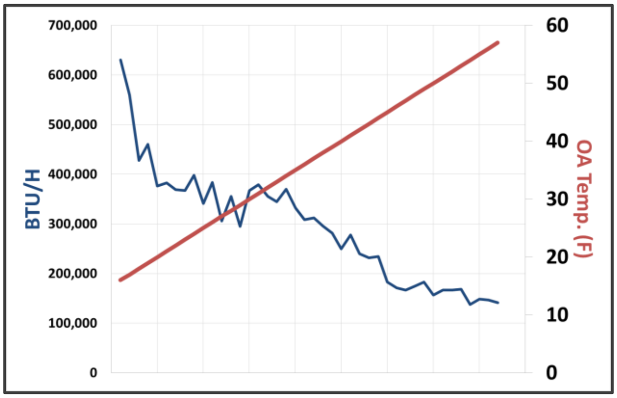
LOCAL ELEMENTARY SCHOOL
OAT VS. CHILLER TONS
76,000SF/90 TONS = 844SF/TR



LOCAL ELEMENTARY SCHOOL

OAT VS. BOILER

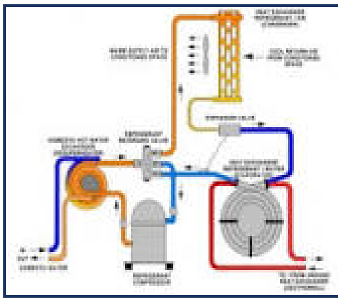
650,000BTUH/76,000SF = 8.5BTUH/SF

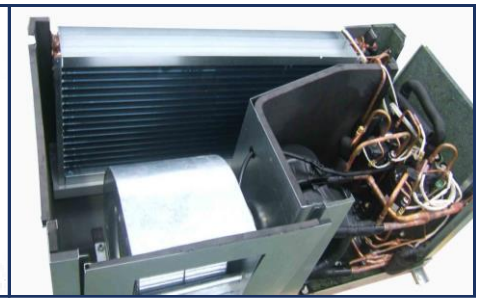


OPTIMUM HVAC SOLUTIONS

- 50% More Efficient
- Lower First Cost
  - Smaller Chillers, Boiler, and Pumps
  - Smaller Electrical Distribution System
  - Need Fewer Controls
- Simpler to Operate
- Lower Maintenance Requirements
- Last 25 vs. 15 Years
- Reduces Carbon Footprint
- Set us up for Lower Renewable Energy Costs

CONVENTIONAL GEOTHERMAL SYSTEM
COMPLICATED WATER SOURCE HEAT PUMPS THROUGHOUT THE BUILDING





ENHANCED GEOTHERMAL
CLOSE TO COST OF BOILERS/CHILLER SYSTEM

GEOTHERMAL FIELD

50% SMALLER

THANK YOU!

Wade Brosius
wadebrosius@cm3inc.com

Bob McGreevy, PE
bobmcgreevy@cm3inc.com

CM3 Building Solutions