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HVAC "Basic Science"- System Capacity

- Btu/hour, btu/h, b/h, btuh…. btu ??
- 1 MBH = 1000 btu/hour
- 1 KBH = 1000 btu/hour
- 1 ton of cooling= 12,000 btu/hour
- 1 watt = 3.414 btu/hour
- 1 kilowatt = 1000 watts = 3,414 btu/hour
- 1 HP = 746 watt = 2,545 btu/hour

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HVAC Airflow- Duct and Component Sizing

- **CFM**- volume of airflow; cubic feet/minute
- **FPM**- velocity/speed of airflow; feet/minute
- **AREA-** duct size in ***square feet***

CFM = FPM X AREA

FPM = CFM/AREA

AREA= CFM/FPM

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Indoor Environmental Quality (IEQ)

<u>Title 24- Minimum Ventilation Requirements</u>

- Applies to “normally occupied” spaces
- Natural ventilation-
  - 20’ maximum distance from occupied space to window/wall opening
  - 1 sq ft of opening for 20 sq ft of floor area (NOTE: “free area” of opening)
- Mechanical ventilation
  - EF’s and makeup air
  - Required for areas with moisture (showers)

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IEQ- Ventilation Systems

Natural "Passive" Ventilation

- motorized clerestory windows
- filtered low-wall intake louvers

Mechanical Ventilation

- 15 CFM per person OR 0.15 CFM/sq ft
- Air change calculation- **# AC/hour**

$$\text{CFM req'd} = \frac{(\text{Room volume- FT3})(\text{\# AC/hour})}{60}$$

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Passive Ventilation- CHPS project

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IEQ- Economizers

- Provide "free" cooling for space if OSA temp is below space temperature (i.e. 72F)
- T24 requirement for systems > 2,500 CFM and 75 MBH (appx 6.25 tons)
- BEWARE!! Motorized dampers need maintenance
- Where does all this OSA go?…building pressure problem!
  - Power exhaust
  - Barometric relief

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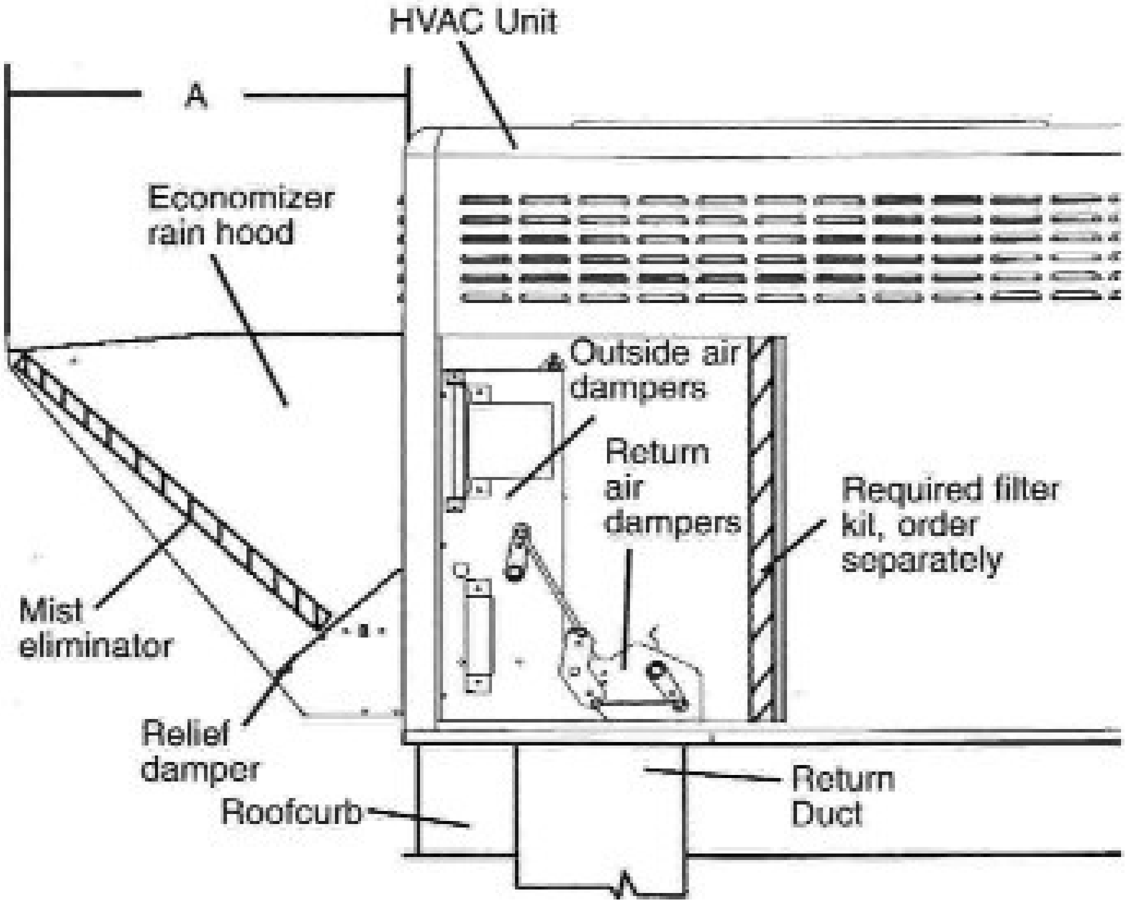
Economizer (rooftop package unit)



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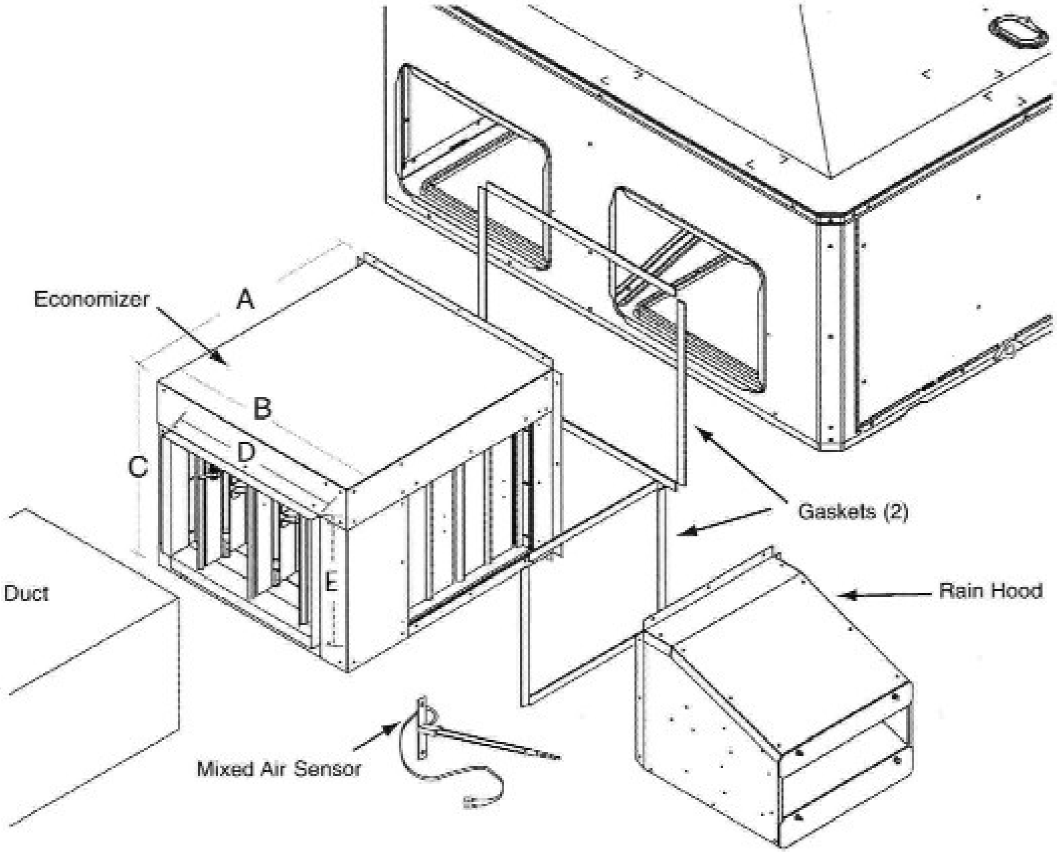
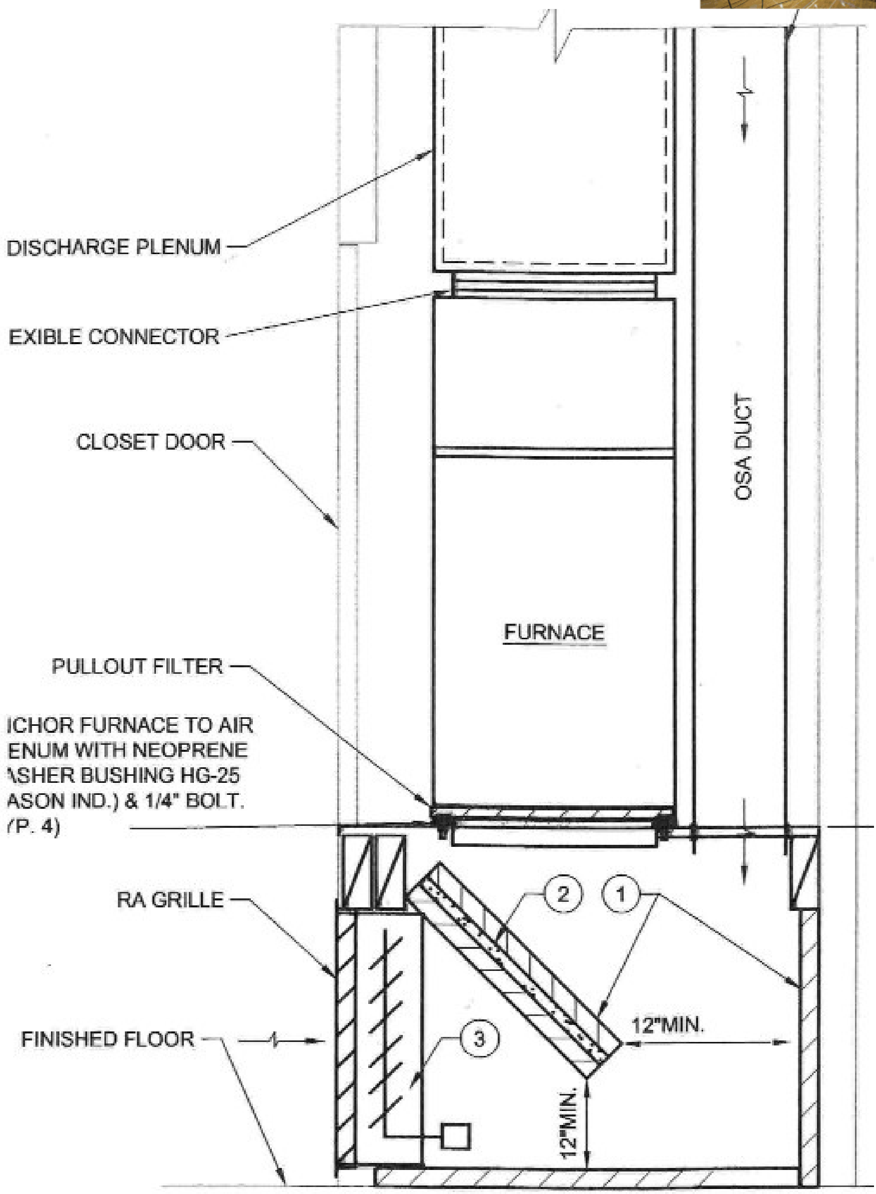
Economizer (rooftop package unit)



Economizer (split system)



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IEQ- Ventilation Methods

Demand Controlled Ventilation (DCV)

- Mandatory for high occupancy zones (less than 40 ft2 per person density)
- CO_2 sensor controls economizer dampers
- Classrooms are exempted (but still worth considering!)

Displacement Ventilation

- Underfloor vs. low-wall ducts

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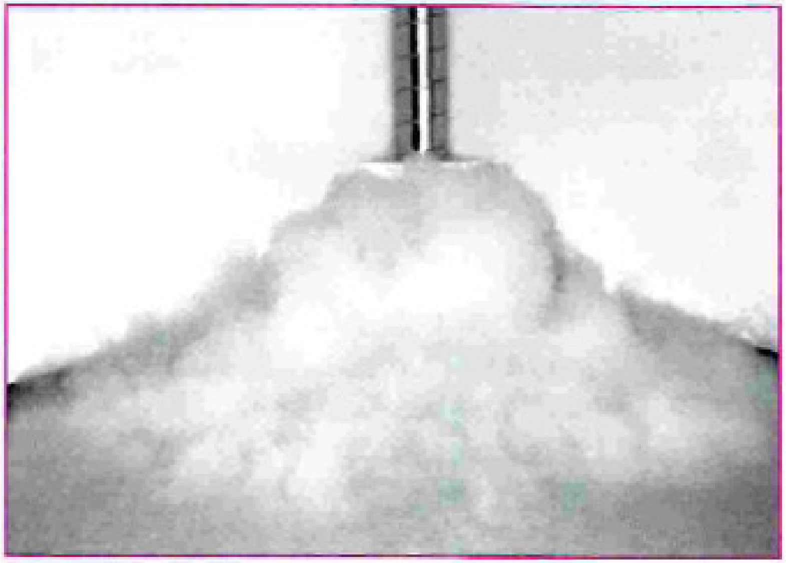
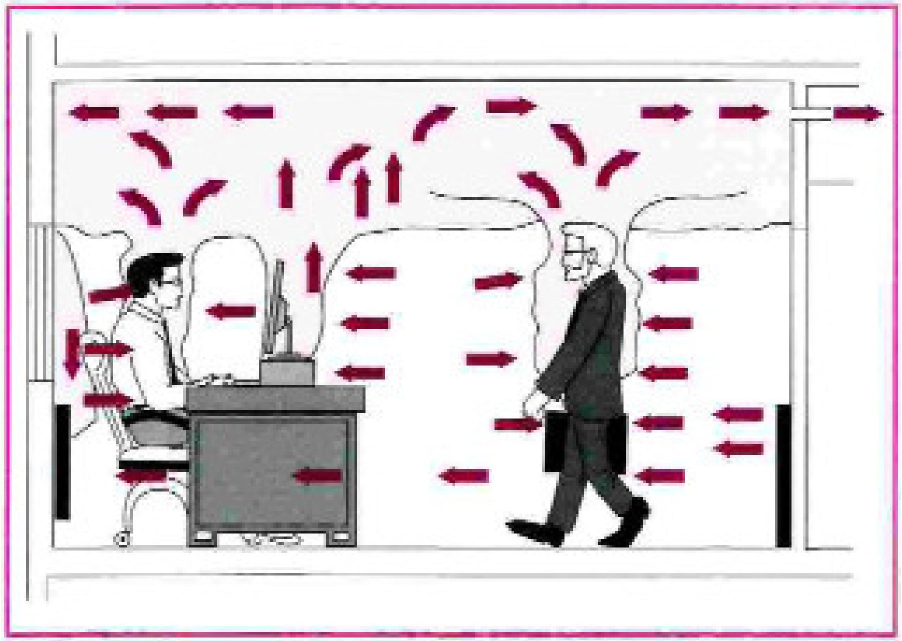
Displacement Ventilation

DR90 - Round Displacement 90°





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IEQ/Acoustics

- Velocity (FPM)
- Damper locations: duct MVD's vs. register OBD's
- Sound traps vs. lined rectangular duct
- CHPS requirements
- RC/NC levels

BLACH CONSTRUCTION

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HVAC System Types

- Energy Recovery Ventilators (ERV’s)
- Evaporative Cooling (Direct vs. Indirect)
- Heating systems
- Refrigeration Cycle overview
- Refrigerant types (CFC vs non-CFC)
- Split systems (furnaces/fan-coils with CU’s)
- Package units (gas/electrics and heat pumps
- Geothermal heat pumps

BLACH CONSTRUCTION

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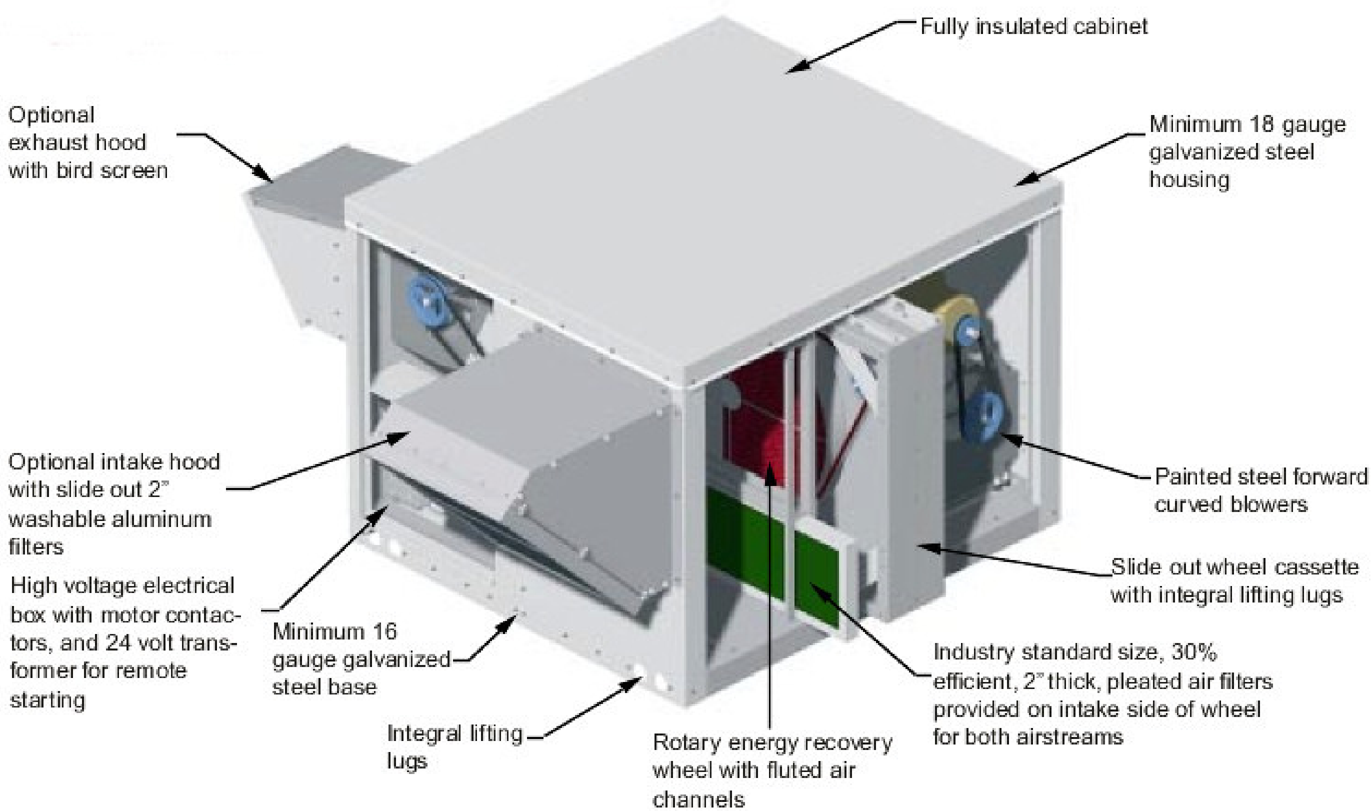
Energy Recovery Ventilators (ERV's)



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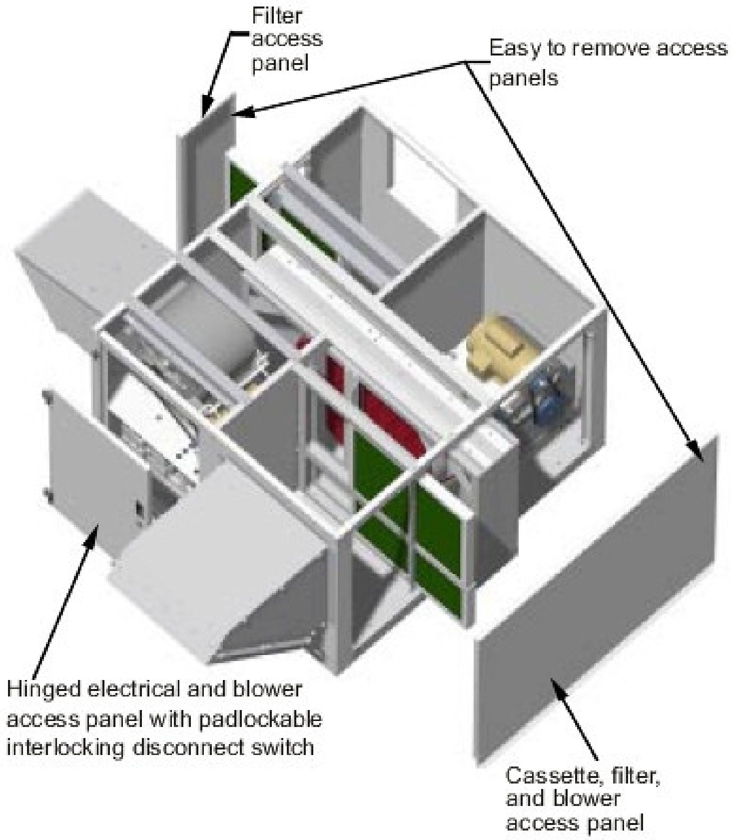
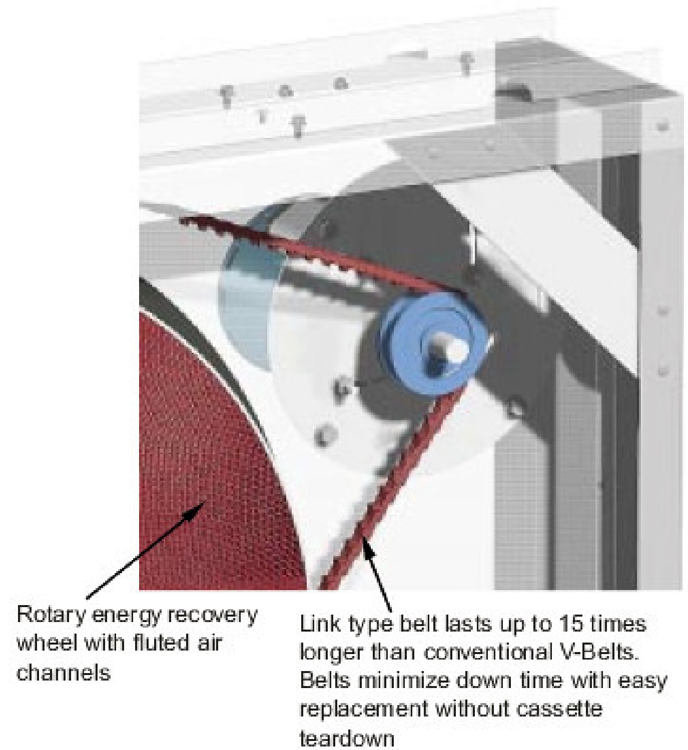
Energy Recovery Ventilators (ERV's)





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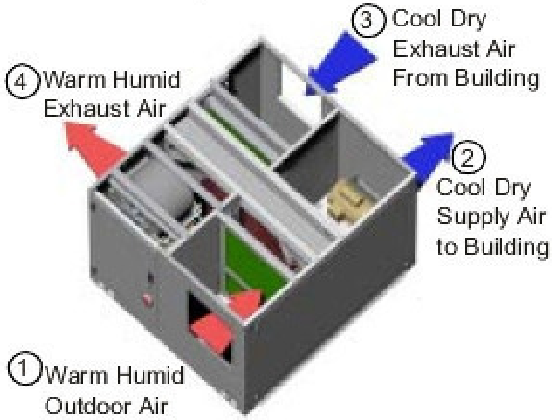
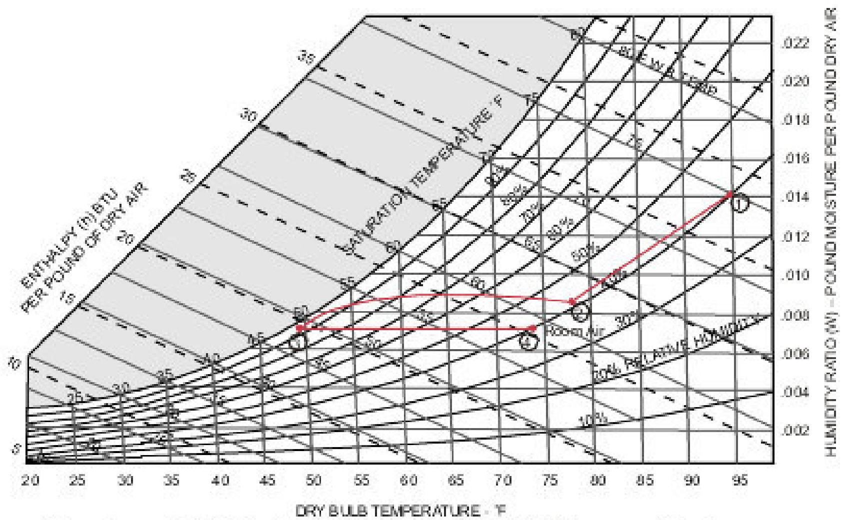
ERVs (how they work)

Summer

- Cools incoming outdoor air through sensible heat transfer and lowers humidity through latent heat transfer. Effectiveness rates are up to 85 percent.
- Allows engineers to reduce HVAC equipment peak load requirements by up to 4 tons per 1,000 CFM of exhaust air.
- The ERV is an ideal solution for reducing HVAC equipment size and maintaining relative humidity levels below 50 percent.





Psychrometric Chart Illustrating Typical ERV Summer Performance

A = Energy required to condition outdoor air to indoor air conditions.
B = Energy reclaimed by an ERV.

$$\%\text{Effectiveness} = \frac{B}{A} = \frac{h_2 - h_1}{h_3 - h_1}$$

Note: For unequal airflow the effectiveness will increase in the airstream with the lower airflow and will decrease in the airstream with the higher airflow.

① 95˚F dry bulb, 75˚F wet bulb, 40% RH, .014 (lb./lb.), 99 (grains/lb.), 38 (BTU/lb.)
② 78˚F dry bulb, 62˚F wet bulb, 41% RH, .008 (lb./lb.), 59 (grains/lb.), 28 (BTU/lb.)
③ 75˚F dry bulb, 60˚F wet bulb, 40% RH, .007 (lb./lb.), 52 (grains/lb.), 26 (BTU/lb.)

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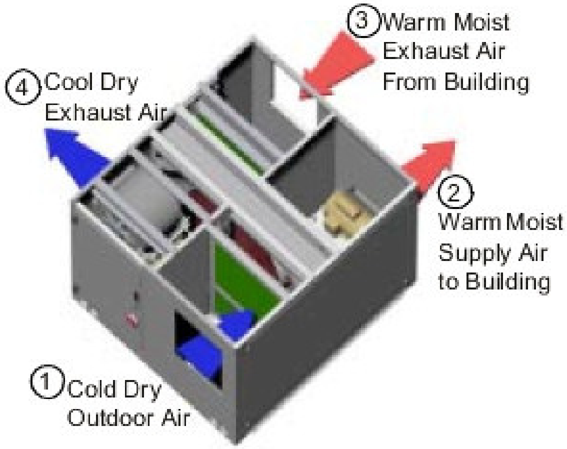
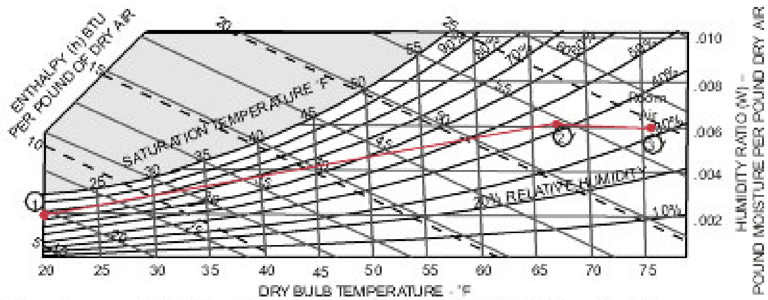
ERVs (how they work)

Winter

- Warms incoming outdoor air through sensible heat transfer and raises humidity through latent heat transfer. Effectiveness rates are up to 85 percent.
- Allows building owners to conserve up to 60,000 BTU per 1,000 CFM.
- The ERV is an ideal solution for reducing energy use and maintaining relative humidity levels above 25 percent.





Psychrometric Chart Illustrating Typical ERV Winter Performance

A = Energy required to condition outdoor air to indoor air conditions.
B = Energy reclaimed by an ERV.

$$\%\text{Effectiveness} = \frac{B}{A} = \frac{h_2 - h_1}{h_3 - h_1}$$

Note: For unequal airflow the effectiveness will increase in the airstream with the lower airflow and will decrease in the airstream with the higher airflow.

① 20°F dry bulb, 18°F wet bulb, 75% RH, .002 (lb./lb.), 11 (grains/lb.), 7 (BTU/lb.)
② 67°F dry bulb, 54°F wet bulb, 43% RH, .006 (lb./lb.), 42 (grains/lb.), 23 (BTU/lb.)
③ 74°F dry bulb, 59°F wet bulb, 38% RH, .007 (lb./lb.), 48 (grains/lb.), 25 (BTU/lb.)

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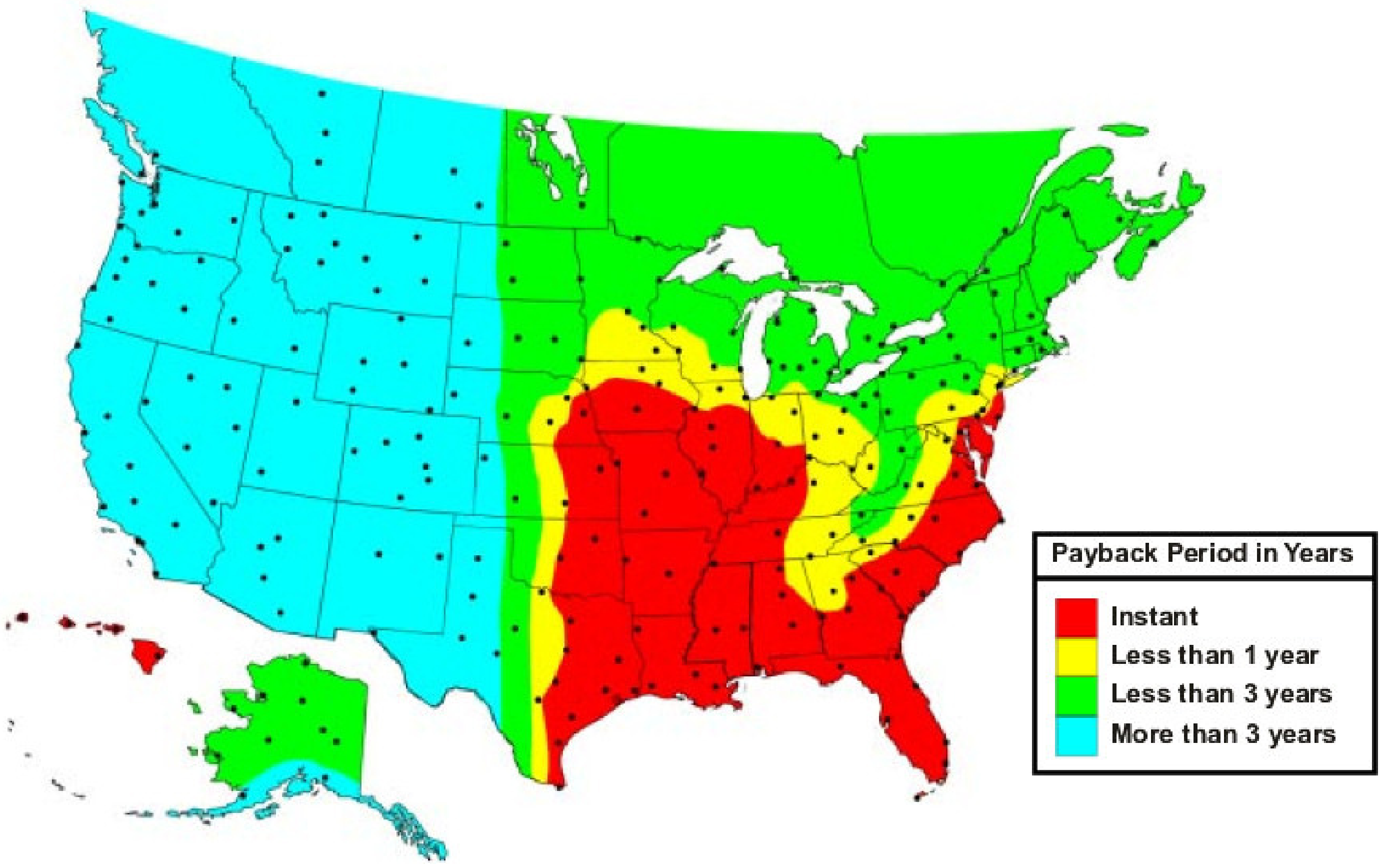
ERV's- Economics/Simple Payback

Payback Map



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Heating Equipment and Systems

<u>Residential Furnaces-</u>

Standard efficiency furnaces 80% AFUE

AFUE: (Annual Fuel Utilization Efficiency) = $\frac{\text{output capacity(btu/hr)}}{\text{input capacity (btu/hr)}}$

High efficiency "condensing furnaces" 92-95% AFUE

PVC flue material

Condensate neutralizers on condensate drains?

Configuration: Downflow/Upflow/Horizontal flow

R.O.T. sizing = 50 btu/hr per square foot of floor area

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Evaporative Cooling
(no refrigeration/mechanical cooling)

“Direct” (swamp coolers)

- Evaporated water in contact with air
- Useful in dry climates

“Indirect”

- Evaporated water NOT in contact with air
- Large/heavy units

Combo “Direct/Indirect” (IDEC units)

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Basic Refrigeration Cycle Components

- Refrigerant- “magic fluid”
- Compressor- increases refrigerant pressure and temperature; performs work
- Condenser coil- Heat rejection
- Refrigerant metering device (TXV or capillary tube)
- Evaporator coil- delivers cooling to space
- Refrigerant piping- suction/liquid/hot gas lines

Refrigerant types

CFC's (chlorinated fluorocarbons**)---BAD!**

- R-11 or R-12
- Effect on earth's ozone layer/global warming

HCFC's (hydrogenated CFC)---**BETTER!!**

- R-22
- Phased out by 2020

New Refrigerants- R-134a; R-410a; "Puron" ---
BEST!!!

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Split System Cooling/Heat Pumps

- Furnace compatibility with “cased cooling coil”
- Outdoor condensing units
  - SEER- “seasonal” Energy Efficiency Ratio
  - Power requirement
- Refrigeration linesets
- Multi-zone “ductless” systems
- Evaporator coil condensate piping and IAQ

BLACH CONSTRUCTION

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Rooftop Package Units

- Typical System Types:

  Package "cooling/only" units

  Package "gas/electric" units

  Package heat pumps

- All above are "air-cooled"

  Typically rated @ 95 F condensing temp

  Watch out for elevated roof temperature

  Good air circulation is a must !

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Rooftop Package Units

- Cooling capacities

1 ton = 12,000 btu/hour

1 ton = 400 CFM (+/- 20% flexibility)

unit capacity = total capacity NOT sensible capacity

(rated @ 95F ambient, 80F edb, 67F ewb)

sensible cooling capacity 70-80% of total

latent capacity provided >what is needed on West coast

gross capacity does NOT include deduction for fan heat

EER (**E**nergy **E**fficiency **R**atio)= $\frac{\text{btu/hr output}}{\text{KW input}}$

BLACH CONSTRUCTION

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Rooftop Package Units

- <u>Heating Capacities:</u>

  1) Gas/electric units-

     Input capacity (1 MBH = 1000 btu/hr)

     Output capacity (1 MBH = 1000 btu/hr)

     Efficiency = output MBH/input MBH

     Title 24 minimum efficiency= 80%

     Typically “low heat” models used in California

     “Aluminized steel” heat exchangers (SS as option)

Rooftop Package Units

- <u>Heating capacity (cont.):</u>

  2) Package Heat Pumps-

     heat is generated by refrigeration compressors

     reversing valve changes function of evaporator and condenser

     heat output is a function of OSA temperature

     COP (**C**oefficient **O**f **P**erformance)

     auxiliary electric heaters needed for cold winter A.M.and defrost cycle

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Rooftop Package Units

Advantages:

- inexpensive
- fast delivery/installation
- simple to design and operate
- “air-side”economizers
- ratings from manufacturers are certified
- if system fails, only 1 zone affected
- easy to meter for utility billing purposes
- installed on roof for easy maintenance

Disadvantages:

- limited flexibility to select/change components
- higher operating & maintenance cost than “central systems”
- not good for tight temperature/RH control
- not good for high % of OSA
- looks not appealing
- filtration options limited
- fan performance limited (particularly static pressure)
- shorter equipment life