Association for Energy Affordability

Asit Patel, Nick Dirr, Angel Moreno, Andy Brooks

Building Assessment and Energy Audits of Multifamily Buildings (High Rises)

Stated session objectives:

- Understand what to look for during an energy audit of a multi-family buildings;
- Know what diagnostic, health, and safety tests to conduct;
- Learn what data to collect; and
- Discover how to select cost-effective Weatherization measures for multi-family buildings.

Before we get into discussion about MF audits - Lets talk about some differences between MF and SH

- Who is WAP client in MF buildings?
- Who applies for WAP services?
- Who pays for utilities?
- Who is responsible for day to day operation of the building?
- Who decides what measures are implemented?

Who is WAP client in MF buildings?

- Income eligible households.
- Building owner is a partner (conduit) needed to deliver WAP services to income eligible households.
- Needed to make investment to implement comprehensive energy conservation measures in the building.

Who applies for WAP services?

- Building owner applies for WAP services.
- Building owner's partnership is very critical.

Who PAYS for the utilities?

- Before you begin the audit process, in my opinion, this is the **MOST** critical question that needs to be answered.
- WHY?
  - Master metered Vs. Direct metered
  - HUMAN BEHAVIOR!!!

Who is responsible for day to day operation?

- Typically someone other than the owner.
  - NO SELF INTEREST.
  - No incentives.

Who decides what gets installed?

- Auditor.
- Based on energy audit.
- Owner also plays major role in decision making (unlike 1-4 unit).

Energy audit – How it differs

- Multiple parties are involved – not just service provider and the client.
- Every group is looking to serve their own interest.
- Multiple fuel consumption sources – must collect from all sources otherwise the analysis could be flawed.
  - Ex. Less heat from central plant – tenant supplement heat by space heaters or ovens.

Energy audit – How it differs

- Analysis is based on averages rather than some specific setting or set measurement.
- Controls with definitive settings are rare.
- Space temperature balancing is a major issue.
- Analysis tool will report lowering of temperature will provide "**X**" % savings, but requires knowledge of how you will achieve this goal.

It's the auditor stupid…..

- Software analysis tools are just that
- **A TOOL**
- It is the experienced auditor who decides what measures need to be implemented in the building……..

And now you will hear the rest of the story…….

MUTLI-FAMILY HEATING SYSTEMS

NYC Multi-Family Heating Systems

- Typically Heating and DHW combination
- Mostly 1-pipe Steam Systems
  - Supply and return share similar distribution piping
- Also 2-pipe Steam Systems
- Hydronic Systems

NYC Multi-Family Heating Systems

- Fuels are #2, #4, #6 Oil and Natural Gas (no propane in NYC)
- Common to see dual fuel systems (usually requires an in-depth billing analysis)
- Some electric baseboard systems
- Rarely see forced-air central furnaces

Scotch Marine Boilers

- Most common, usually with tankless coil for DHW generation

Cast-Iron Boilers

- Usually in boiler rooms where space is an issue

Atmospheric Boilers

- Steam and Hydronic, Least Efficient, Usually in Modular Set-Up

Boiler Room Investigation

- Boiler-plate Info - Input Capacity
- If not available, need to do some detective work to find out input capacity
- Conduct Combustion Efficiency Test
- Inspect Boiler Shell
- Near Boiler Piping
- H&S

Boiler Room Investigation

Boiler Room Investigation

Boiler Room Investigation

Boiler Controls

- Pressure Control Settings for Steam Boilers >>> Turn it Down!
- Aquastat settings for Hydronic Boilers and DHW
- Boiler Control Systems
  - Cycle Control Systems
  - Outdoor Reset Systems
  - Interior Feedback / in-unit sensors

Controls Investigation

Controls Investigation

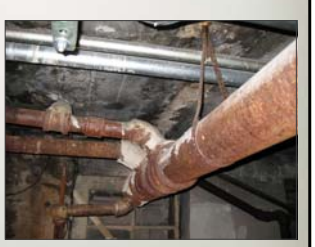
Distribution System (steam)

- Pipe Insulation
- Air Vents
- Raditator Pitch

Distribution System (hydronic)

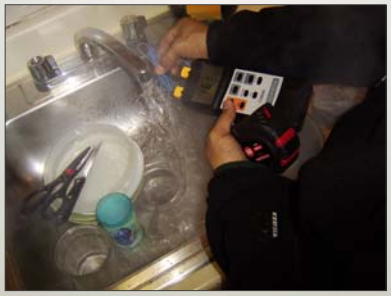
- Pipe Insulation
- Pumps
- Convectors and Radiators
  - Condition
  - Trapped air (air bleeding necessary?)

Distribution Investigation

Distribution Investigation


DHW Investigation



In-Unit Temperatures

- Best and most accurate time is in Winter
  - summer info based on tenant and super inverviews and modeling
- Identify symptoms of over-heating
  - Look for Open Windows in Winter

Overheating?

In-Unit Temperatures

- Typically when modeling, use average temperature through the building
- Identify locations of serious temperature imbalances
  - could be due to vents/condensate block (steam)
  - Broken steam traps (2 pipe steam)
  - Air elimination issues (hydronic)

Common Boiler Recommendations

- Repair Steam boilers
  - clean firetubes, repair or upgrade burner
  - Repair near-boiler piping

Common Boiler Recommendations

- New Steam boilers
  - Limited effiency
  - Fully modulating burner
  - Improved Header Design to maximize hot-dry steam
  - New Pressure controls (limit operating pressure to <4 psig)

Common Boiler Recommendations

- New Hydronic boilers
  - High Efficiency and Condensing (if natural gas)
  - Variable Speed Pumps
  - Outdoor reset controls

Building/Energy Mangement Systems

- Steam Heating-Cycle controls
  - Outdoor temperature sensor with in-unit sensors to adjust cycles based on both
  - Internet controls for building managers

Building/Energy Mangement Systems

- Hydronic Heating controls
  - Outdoor reset controls
  - Staging and Modulation controls

Distribution Measures

- Insulate heating pipes!
- Repair or replace airvents, hand valves, and repitch radiators
- Install TRVs for 2-pipe steam and hydronic (especially where overheating takes place)
- Clean, repair, or replace baseboard convectors where nessary

DHW Recommendations

- Install Low-Flow showerheads and faucet aerators
- Repair or replace mixing valves so that tap temps are < 130° F
- Insulate DHW Pipes
- Install seperate DHW system
  - Condensing where possible (natural gas and venting capable)
  - Storage tanks for tankless coils

KNOWLEDGE

CATEGORIES OF KNOWLEDGE

1. the KNOWN and PERMANENT

CATEGORIES OF KNOWLEDGE

1. the KNOWN and PERMANENT
2. the KNOWN and CHANGING

CATEGORIES OF KNOWLEDGE

1. the KNOWN and PERMANENT
2. the KNOWN and CHANGING
3. the UNKNOWN

THE KNOWN AND PERMANENT

examples

1. building construction
2. building location & orientation
3. building size

THE KNOWN AND CHANGING

examples

1. ambient temperature
2. equipment run time
3. occupant schedules
4. equipment efficiency

THE UNKNOWN

examples

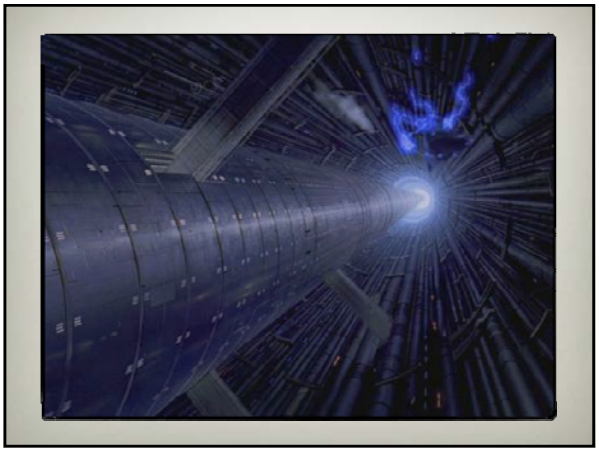
1. apartment plug loads
2. presence or amount of insulation
3. infiltration rate - no blower door?!

EXPLORING THE UNKOWN

- take a look inside

EXPLORING THE UNKOWN

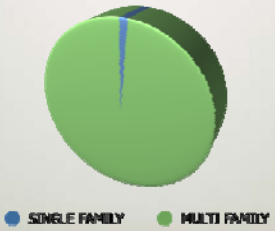
- take a look inside



ELECTRICAL

ELECTRIC

appliance comparison



REFRIGERATORS

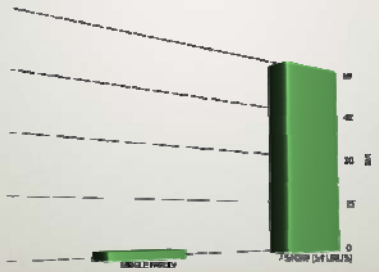
existing:

- 400 - 900 kWh per year

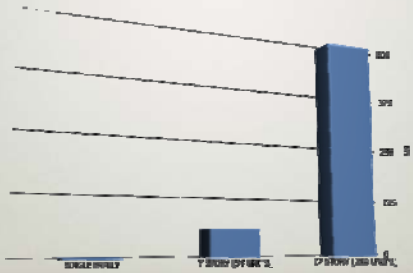
considerations for replacement:

- what is the electric rate?
- who owns the appliance?
- interactive effect on heating load

LIGHTING



LIGHTING



LIGHTING

need to know

1. how many
2. what type
3. wattage
4. run time

LIGHTING

fluorescent lamps

watts

lumens

CRI

color temperature

LIGHTING

CRI - color rendering index

scale of 1 to 100

100 represents natural/daylighting

'cool white' bulb has CRI of 62

LIGHTING

color temperature

measured in Kelvin

the higher the temp, the cooler the color

incandescent: 2700K

metal halide: 5000K

LIGHTING

compact fluorescents

LIGHTING

lumens

perceived light output

degrade over time: initial vs mean lumens

LIGHTING

luminous efficacy: lumens per watt

lamp type	initial lumens	mean lumens	watts
T5	2900	2726	28
T6	2725	2560	28
T7	2850	2680	30
T8	2850	2710	32
T9	3050	2775	40

also depends on ballast type...

LIGHTING

effective lumens: lumens x ballast factor

ballast type		ballast factor
magnetic	rapid start	0.83
electronic	instant start	0.94
electronic	programmed start	1.00

LIGHTING

HID: high intensity discharge

metal halide has better CRI and color temp than high pressure sodium

MH 100 watt

mean lumens: 6200

HPS 100 watt

mean lumens: 9500

LIGHTING STRATEGIES

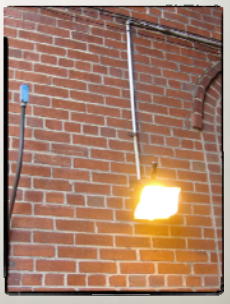
- how much light do you need?
- ASHRAE recommends:

space	W/sqft
building area	0.7
lobby	1.3
corridors	0.5
stairs	0.6
living space	1.1
parking garage	0.3

LIGHTING

LIGHTING

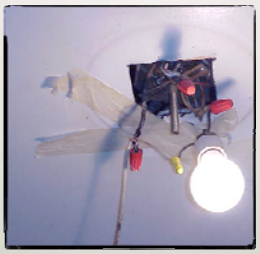
LIGHTING STRATEGIES



LIGHTING STRATEGIES

- timers

LIGHTING



SAVINGS POTENTIAL

percent of electrical savings in comprehensive scope

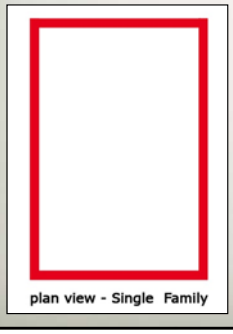
refrigerator replacement:	10%
public lighting replacement:	15%
apartment lighting:	20%

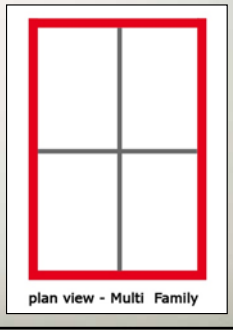
THERMAL BOUNDARY

CORE vs SHELL

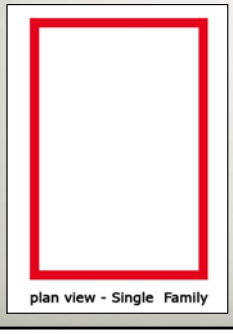
- the ratio of
- Exterior Surface Area to Heated Area
- is smaller in a high rise
- than in a single family home

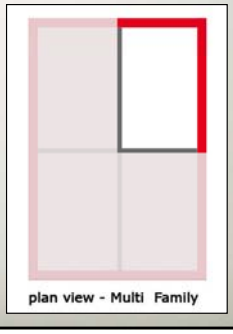
THERMAL BOUNDARY


plan view - Single Family

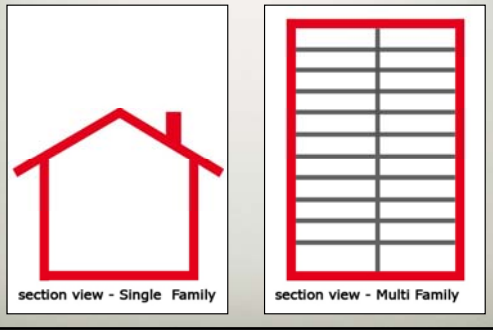

plan view - Multi Family

THERMAL BOUNDARY

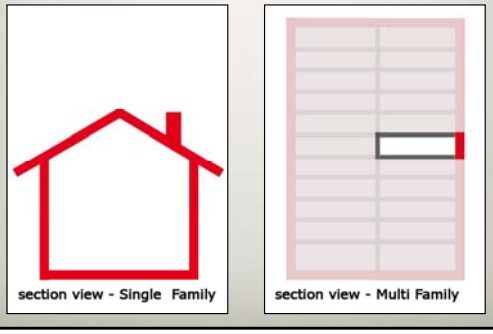

plan view - Single Family


plan view - Multi Family

THERMAL BOUNDARY



THERMAL BOUNDARY



CORE vs SHELL

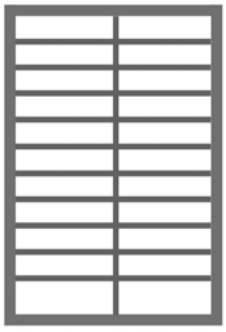
1. heat transfer through external surfaces is less significant in a high rise
2. internal gains dominate

PRESSURE BOUNDARY

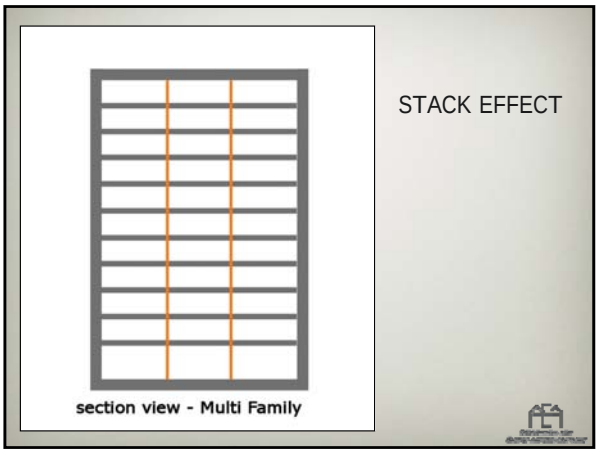
STACK EFFECT

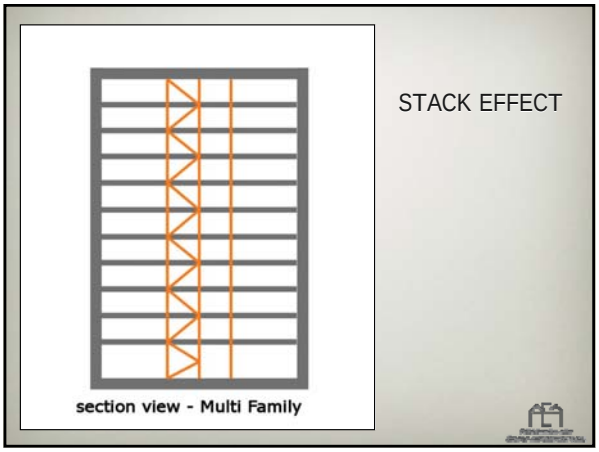
1. important!
2. heated air will seek upper floors
3. positive pressure builds in upper floors
4. negative pressure on lower floors

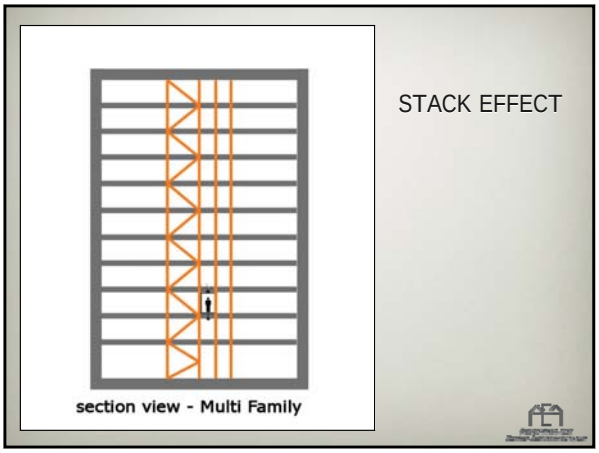
STACK EFFECT

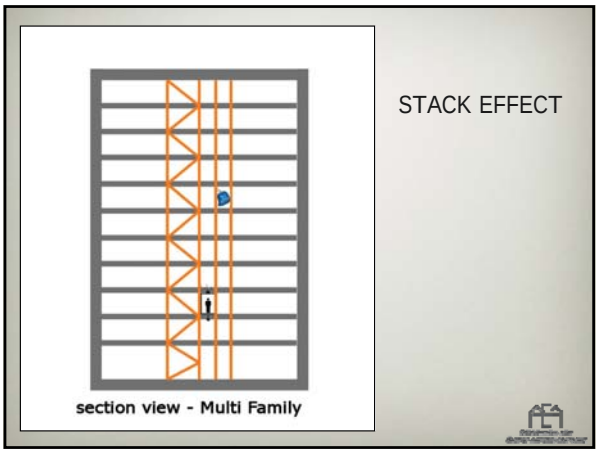


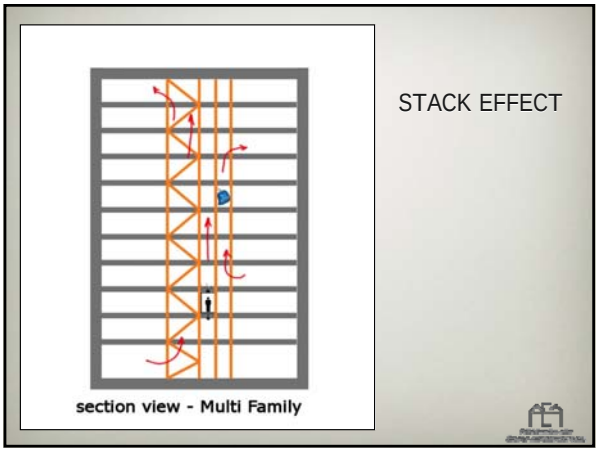
section view - Multi Family

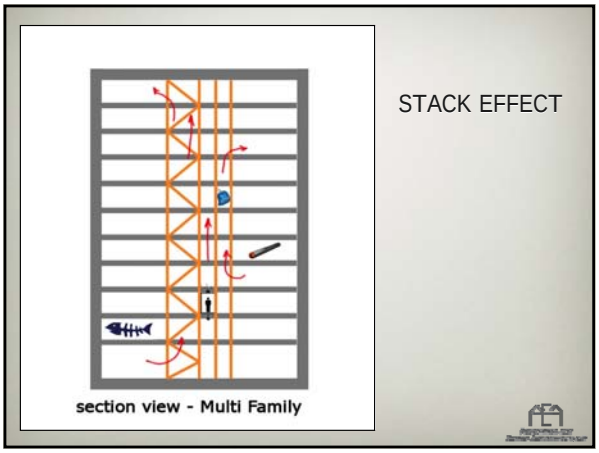

STACK EFFECT
section view - Multi Family

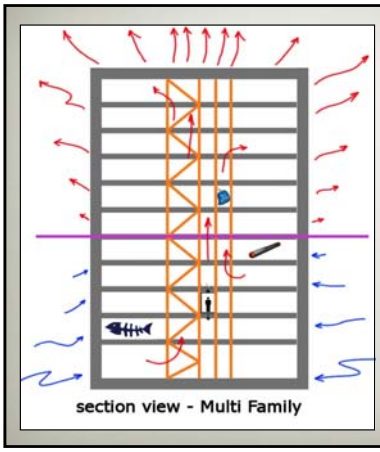

STACK EFFECT
section view - Multi Family


STACK EFFECT
section view - Multi Family


STACK EFFECT
section view - Multi Family


STACK EFFECT
section view - Multi Family


STACK EFFECT
section view - Multi Family



STACK EFFECT

STACK EFFECT

pathways

1. ventilation
2. plumbing
3. elevator
4. stairwells
5. garbage chutes

STACK EFFECT pathways

- evidence of air movement

STACK EFFECT

pathways

STACK EFFECT

pathways

STACK EFFECT

pathways

STACK EFFECT

infiltration invasion

SOLUTION: DIVIDE & CONQUER

•mitigate the stack effect by compartmentalizing

1. isolate stairwells
2. seal ventilation shafts
3. seal garbage chutes
4. seal the top & bottom of the building
5. seal in unit plumbing & heat piping
6. isolate basement & mechanical rooms

HEALTH AND SAFETY

- What happens in case of fire in a high rise building?
- Does the building have a designed ventilation system?

THE ENVELOPE

walls

ENVELOPE: WALLS

need to know

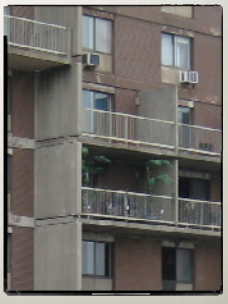
1. assembly r-value
2. wall area
3. area of windows & doors in wall
4. wall orientation
5. shading (trees/other buildings)

ENVELOPE: WALLS

1. concrete block
2. face brick
3. minimal insulation (if any)
4. interior lath and plaster finish

ENVELOPE: WALLS

ENVELOPE: WALLS



RECOMMENDATIONS

1. re-point
2. seal holes

RECOMMENDATIONS

1. re-point
2. seal holes

what about insulation?

RECOMMENDATIONS

1. re-point
2. seal holes

what about insulation?

no wall cavity

core dominated loads

interior partitions prohibit continuity

THE ENVELOPE

windows

ENVELOPE: WINDOWS

need to know

1. assembly u-value
2. window area & count
3. area of windows & doors in wall
4. orientation
5. shading (trees/other buildings)

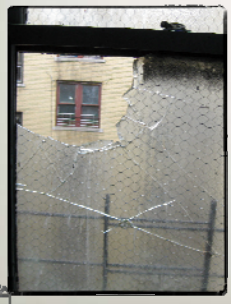
ENVELOPE: WINDOWS

glazing

1. single
2. double
3. low-e coating
4. argon filled
5. this...

ENVELOPE: WINDOWS

ENVELOPE: WINDOWS



ENVELOPE: WINDOWS

- broken balances

ENVELOPE: WINDOWS

RECOMMENDATIONS

1. weather strip & caulk frames
2. repair balances
3. replace windows

RECOMMENDATIONS

replacement considerations

1. frequency of use
2. glazing properties for your climate
3. frames: aluminum vs fiberglass

THE ENVELOPE

A/C SLEEVES

ENVELOPE: A/C SLEEVES

- central A/C systems are not common
- window units and A/C sleeves are both equally prevalent

ENVELOPE: A/C SLEEVES


ENVELOPE: A/C SLEEVES


RECOMMENDATIONS

1. seal
2. insulate
3. install proper cover

THE ENVELOPE

doors

ENVELOPE: DOORS

1. solid with insulated core
2. hollow metal
3. glass with aluminum frame (storefront)
4. vestibule

ENVELOPE: DOORS

ENVELOPE: DOORS

RECOMMENDATIONS

1. weather strip
2. door sweeps
3. replace
4. install self-closing mechanism

THE ENVELOPE

roof

ENVELOPE: ROOF

need to know

1. type of construction
2. r-value
3. area

ENVELOPE: ROOF

ENVELOPE: ROOF

- empty cavity

ENVELOPE: ROOF

parapet walls & flashing

ENVELOPE: ROOF

RECOMMENDATIONS

1. air seal & insulate cavity
2. repair flashing
3. repair leaks
4. correct drainage
5. resurface

THE ENVELOPE

base

ENVELOPE: BASE

1. slab on grade
2. below grade
3. crawl space
4. unconditioned basement?

ENVELOPE: BASE

RECOMMENDATIONS

. . .

SAVINGS POTENTIAL

percent of heating savings in comprehensive scope

air sealing:	1% to 30%
window replacement:	10% to 15%
roof insulation:	15% to 25%

Mechanical Ventilation Systems in Multifamily Buildings

THEY BLOW!!!!!!!

WHEN IN FACT

- They should…….

Suck!!!!!

Multifamily Buildings

- THEY DON'T WORK!
- Over ventilated
- Under ventilated
- EraDiCaLy ventilated
- I n te r m i tt ent ly ve n t ilated
- Upside down, sideways, backwards…you get the point

Why do we care?

- **HUGE and VERY overlooked savings opportunity**
- **Opportunity to improve peoples health and living conditions**

How Are Savings Achieved?

- Uniform & balanced flows from apartment to apartment allow you to decrease overall flows.

	Old Code	New Code
Kitchens	100 CFM	25 CFM
Bathrooms	50 CFM	20 CFM

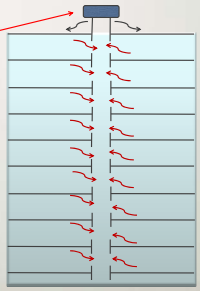
- Decreased flow = Decrease heat loss & Decrease in electrical energy use by fans

Intention of Ventilation Systems

- Removes of air pollutants
- Promotes proper Indoor Air Quality (IAQ)

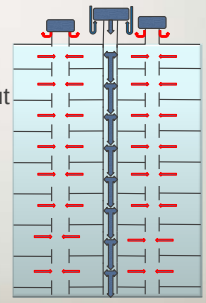
Central Exhaust System

Kitchen or bathroom exhaust fan may serve 1 line or multiple lines via a single vertical riser



"Balanced" System with Supply To Corridors

Intention:
Air coming in = air going out



Typical Layout

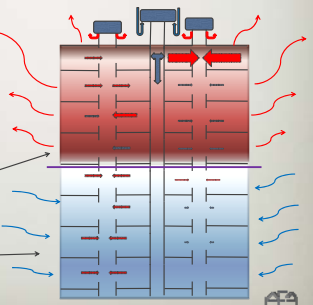
Corridor Supply

Kitchen Exhaust

Bathroom Exhaust

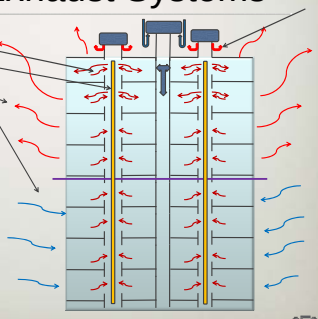
What Is Actually Going On

- Flows are all over the place
- Systems are completely unbalanced
- Stack effect takes over
  - As Delta T between indoor and outdoor increases:
    - top becomes pressurized
    - bottom becomes depressurized



Impact of Stack Effect on Central Exhaust Systems

- Flow through registers
- Static pressure in ducts
- Temperature differential & wind induced stack effect
- Stack pressures increase
- If fans can't compensate for increased pressure and flow
- Increase in flow will look for other ways to get out of the top of the building



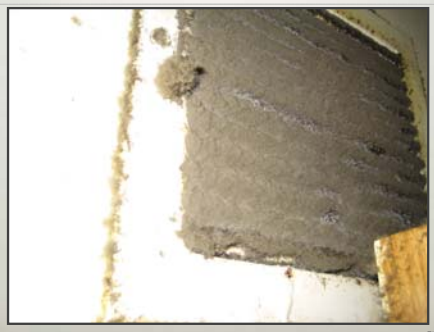
Central Exhaust Systems

Advantages	Disadvantages
• Cheap!	• Difficult to balance • Difficult to maintain • Highly susceptible to fluctuations in system pressures resulting from climatic changes and stack effect • Makes compartmentalization impossible

Causes of Imbalance

- Taped up grilles due to smell transmissions from other apartments, *or* bugs!
- Grilles covered by bookcases or other furniture
- Duct leakage
- Dirty grilles

Not At All Uncommon



Like I said…

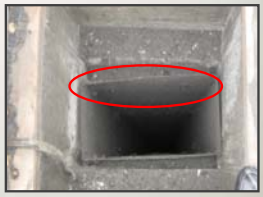
Inspect Condition of Ducts

Masonry Ducts

Sheet Metal Ducts

Two Major Sources of Duct Leakage

1. Termination point between horizontal runout of exhaust riser and sheetrock wall



2. Point at which the vertical riser meets the roof

Test Flow Rates at Registers

Exhaust Fan Flow Meter

Large Vane Anemometer

Test Flow Rates at Fans
(if need be)

What Can We Do To Solve These Problems?

BALANCE

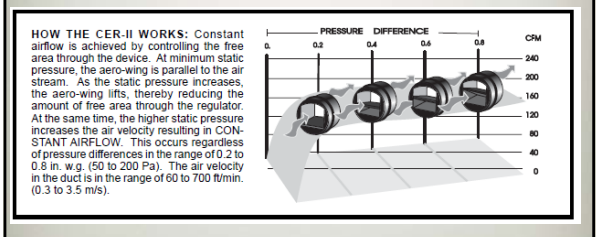
BALANCE

BALANCE

How Do We Balance?

Constant Air Regulators (CAR Dampers)

How Do They Work?

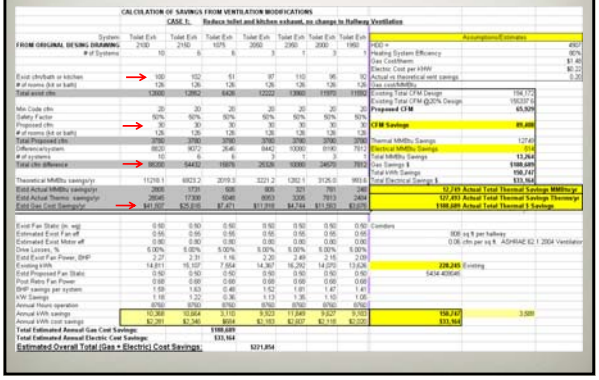


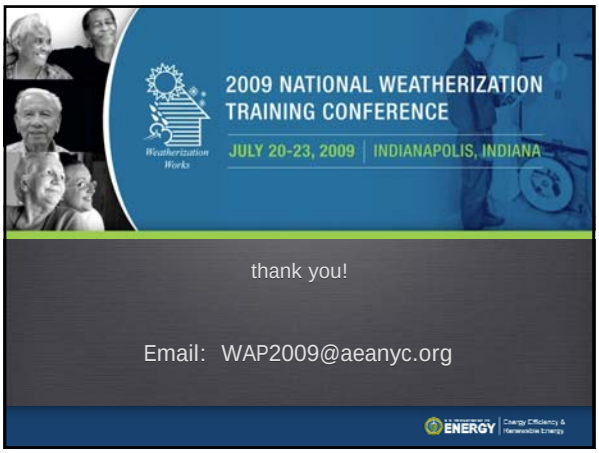
Damper adjusts position based on pressure in the ducts

Replace Belt Driven Fixed Speed Fans

With Direct Drive Variable Speed Fans

How Much Do We Save?




2009 NATIONAL WEATHERIZATION TRAINING CONFERENCE
JULY 20-23, 2009 | INDIANAPOLIS, INDIANA
Weatherization Works
thank you!
Email: WAP2009@aeanyc.org
ENERGY
Energy Efficiency & Renewable Energy