When the Order Matters: A Roadmap for Retrofit

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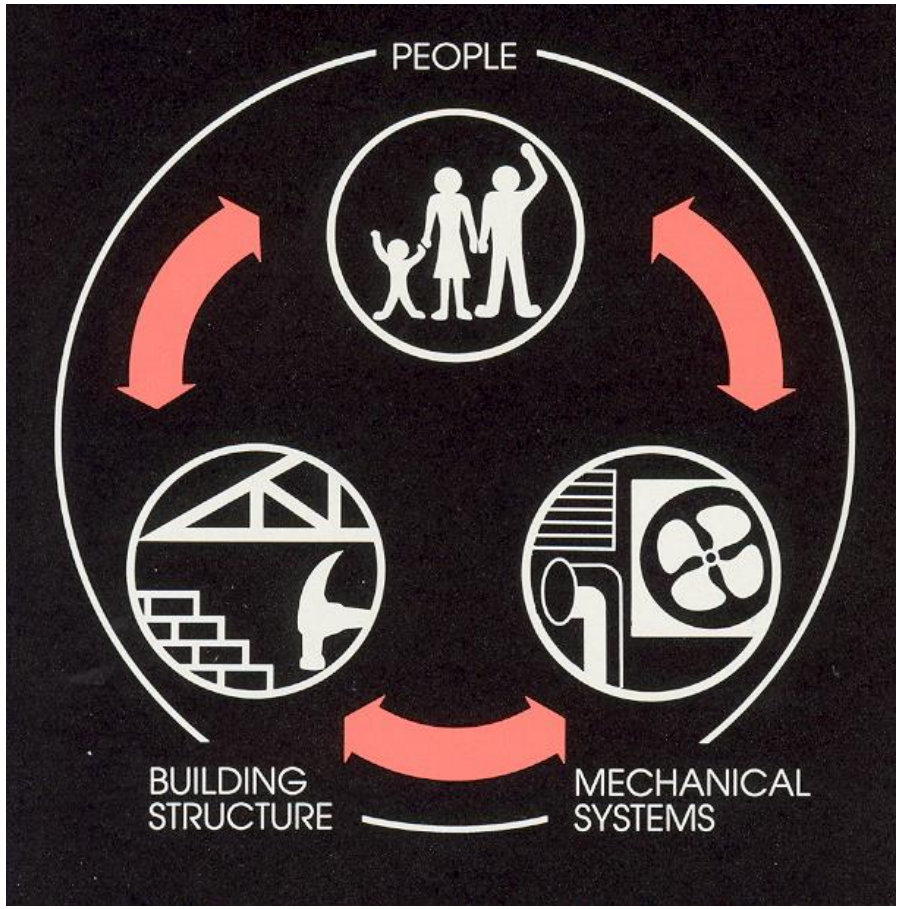
WHEN THE ORDER MATTERS: A ROADMAP FOR RETROFIT

- Context for Today's Presentation
  - We likely all agree that saving energy in our homes has positive economic, social, and environmental value.
  - Minnesota has a strong history of delivering cost-effective, energy efficiency measures for existing homes.
    - In part, because we have highly-regarded weatherization and building performance programs in Minnesota.
  - Minnesota has more than a million homes needing smart, performance-driven energy retrofits.
    - But it's not just about energy!!!

WHEN THE ORDER MATTERS: A ROADMAP FOR RETROFIT

- Part 1: Principles
  - Introducing the Cliff
  - Everything is Connected
  - When The Order Matters
  - What is Risky Remodeling
- Part 2: Developing Whole Building Strategies
  - Role of Testing?
  - Prescriptive vs. Performance
- Part 3: Practices
  - Best of NorthernSTAR

A SYSTEMS-GUIDED, PERFORMANCE DRIVEN APPROACH



- A house is a dynamic system of interconnected parts and components.
- It is driven by the climate, site, indoor conditions, occupants and the laws of physics.
- And depending on how it is designed, constructed, and operated, it may perform …
  - very well,
  - very poorly, or
  - anywhere in between!

USING BUILDING SCIENCE AS YOUR COMPASS

- Study of the physical forces that act on houses
  - Gravity, wind, etc.
  - Heat transfer
  - Moisture transport
  - Air flows
- Application of that knowledge for houses that are …
  - Structurally sound
  - Comfortable and efficient
  - Durable and long-lasting
  - Healthy to live in
  - Friendly to our environment

BUILDING SCIENCE REVIEW

- Energy (Heat Transfer)
  - Transmission losses and gains
  - Air exchange losses and gains
  - Solar and internal gains
- Moisture Movement Mechanisms
  - Gravity (or bulk water)
  - Capillary flow
  - Air transport
  - Vapor diffusion
- Requirements for Airflow
  - Pressure
  - Path
- Indoor Air Quality
  - Source strength and transport
  - Dilution and/or filtration

BUILDING SCIENCE REVIEW

- Heat always moves from warm to cold
- Moisture moves from more to less
- Moisture moves from warm to cold
- Air flows from higher to lower pressure
- CFM (air) out must equal CFM (air) in
- Drain the rain (and the soil)
- Most of the action is at surfaces and connections
- Gas concentration is a function of source strength and removal rate

=> In the end, heat, air & moisture will drive the performance of the system!

ACHIEVING HIGH PERFORMANCE IN EXISTING HOMES

- Building a home or remodeling today is …
  - not just materials, but methods;
  - not just products, but process.

- A home's performance is …
  - Not just components, but connections;
  - Not just actions, but interactions.

REMODELING REALITY

- Home remodeling can be a risky business!
  - Pre-existing conditions
  - Limited budgets
  - Surprises at every turn
- Note: Rehab of vacant or flipped houses is even riskier!
  - Limited data on past performance
  - No occupants to interview / share insights
  - Unknown conditions during vacancy
    - we use energy in our homes to manage moisture!

PART 1A. INTRODUCING THE “CLIFF”

- What is the “cliff”?
  - Health or safety issue
  - Poor material or building durability
  - High operation and/or maintenance costs
- In general,
  - Many homes today are getting closer to the cliff.
  - As we change them, they frequently move closer.
    - It is usually easier, cheaper, quicker to move them towards the cliff, than away from the cliff.

IS THE HOUSE “ROBUST OR FRAGILE”?

- Definitions
  - Robust: strong, healthy, hearty in construction; able to recover from unexpected conditions
  - Fragile: weak and easily broken; unlikely to withstand severe stresses and strains
- In general,
  - Existing houses are becoming more fragile.
  - It takes smaller changes to make bigger impacts.
    - It is getting easier to move towards “the cliff” quicker.

PREDICTING PERFORMANCE OUTCOMES

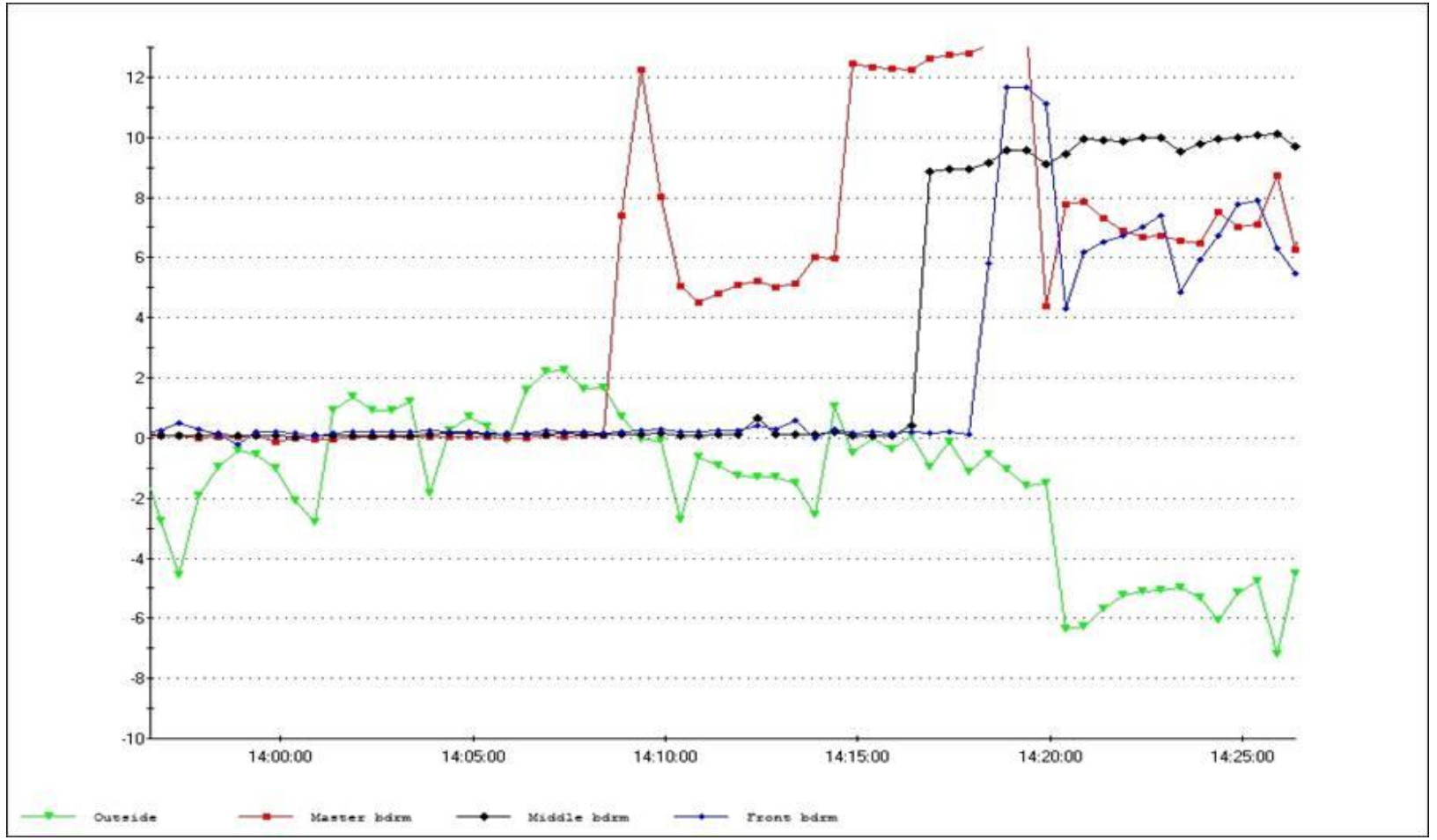
- Your goal is to find out
  - How close the house is to the cliff?
  - How robust or fragile is the house?

- So you can predict
  - How far will you move it?
  - How fast will it move?
  - Will it be towards or away from the cliff?
  - Where will it be when I'm done?

DO YOU HAVE A FRAGILE HOUSE NEAR THE CLIFF?

- Pre-existing conditions
  - CO problems
  - water intrusion/wet basement/mold
  - lead, asbestos, and radon
- Special design concerns
  - fireplace (or wood stove)
  - 1-1/2 story houses
  - tuck under (and attached) garages
  - crawl spaces

CAN CLOSING A DOOR PUSH A HOUSE OVER THE CLIFF?

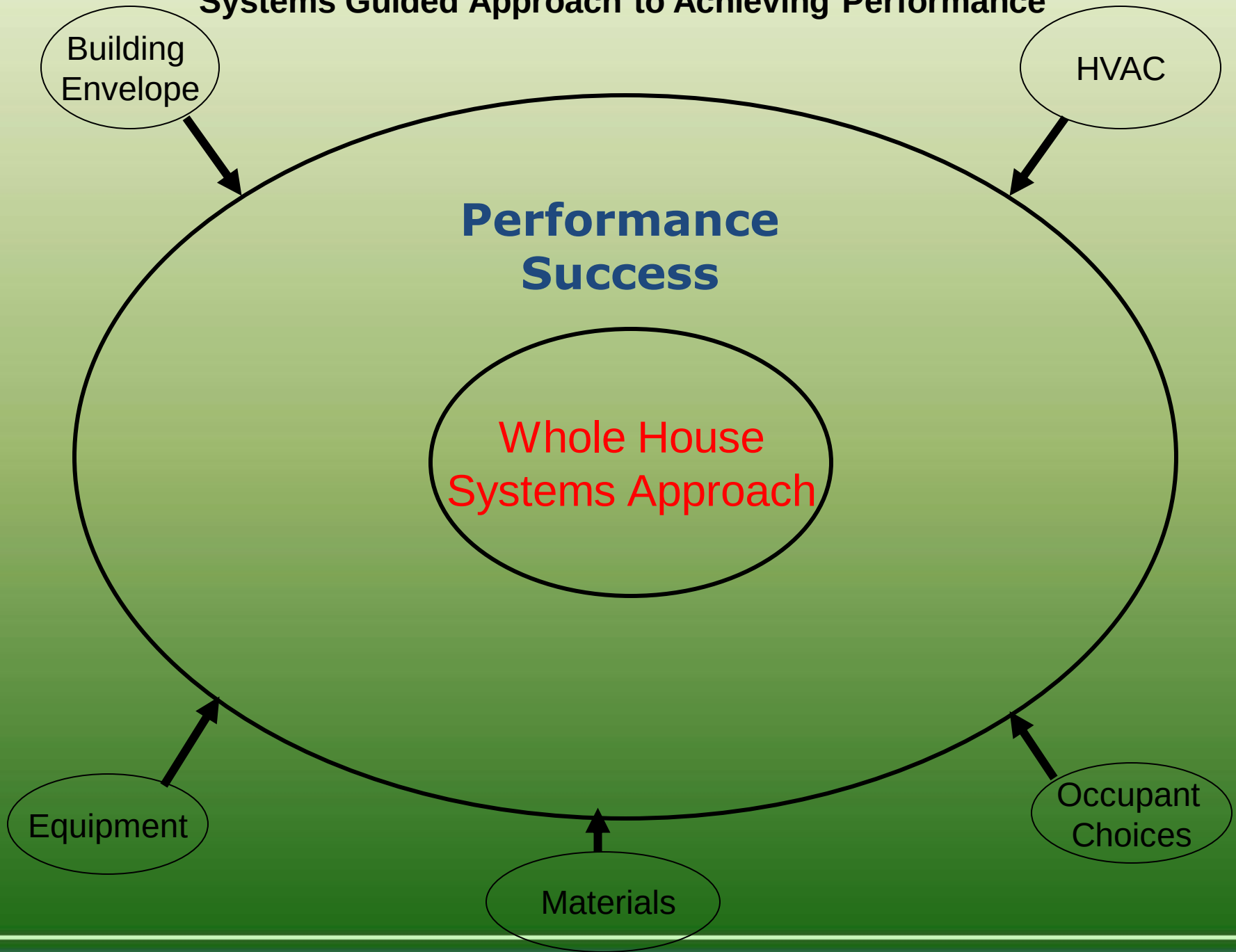


PART 1B. EVERYTHING IS CONNECTED

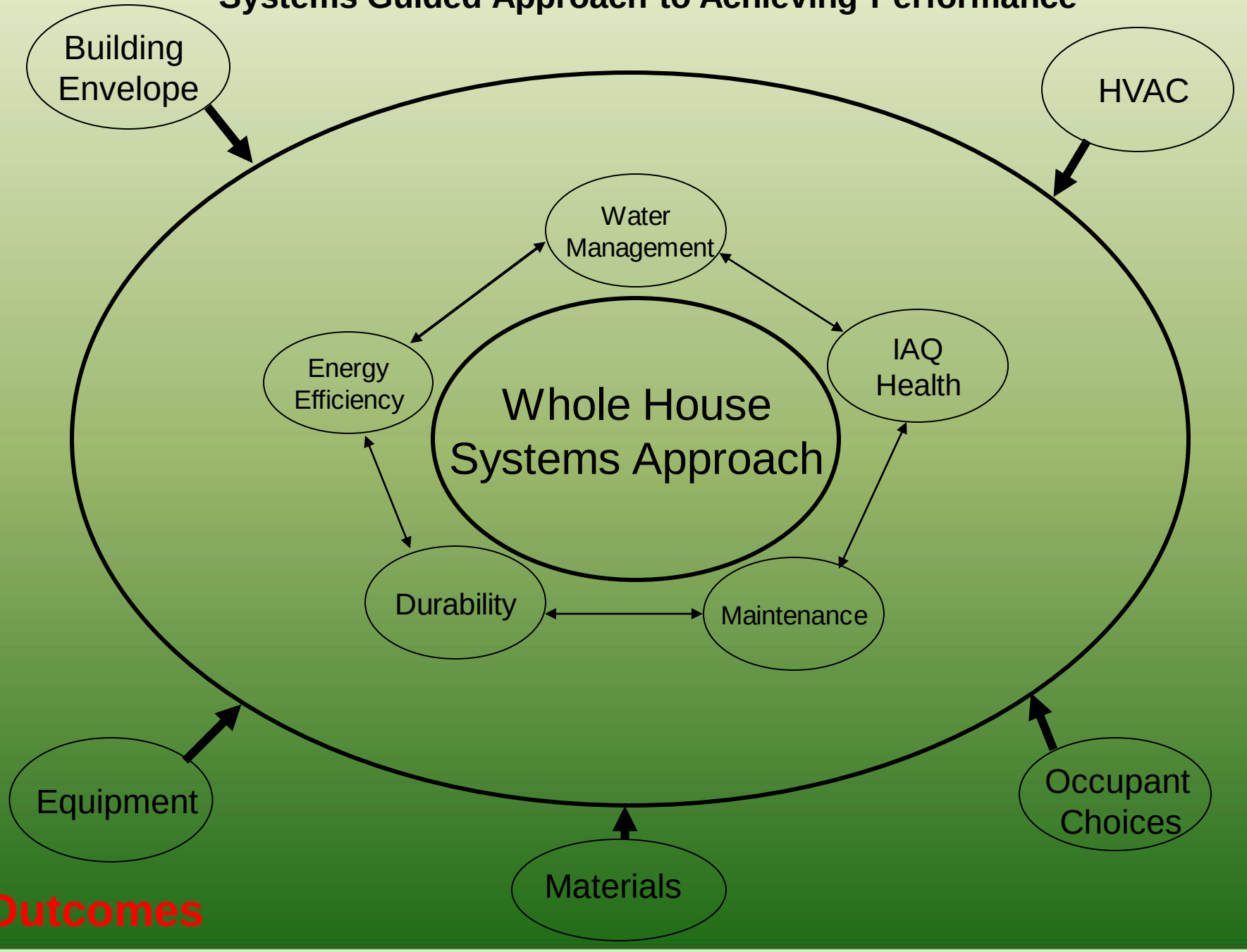
- Energy, durability, and air quality issues are almost always interactive and must be solved simultaneously.
  - Generally better results will be achieved for these items with a performance-based approach.
  - A performance-based approach reduces the risk of improving one area at the risk of another.
  - Performance testing can reduce callbacks and liability.

- With a good understanding of the existing condition and proper commissioning of changes, it is possible to positively affect all three.

Systems Guided Approach to Achieving Performance

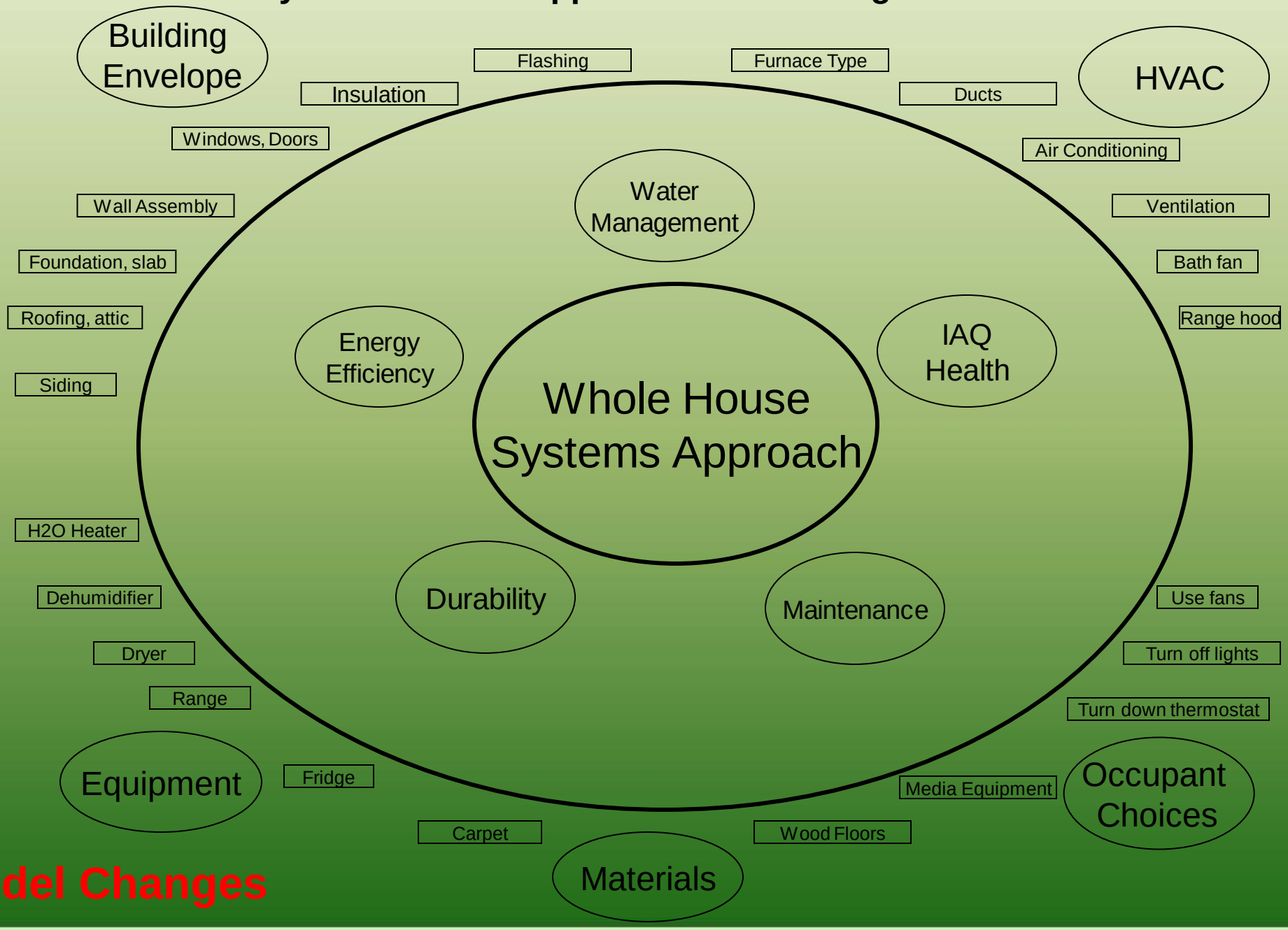


Systems Guided Approach to Achieving Performance



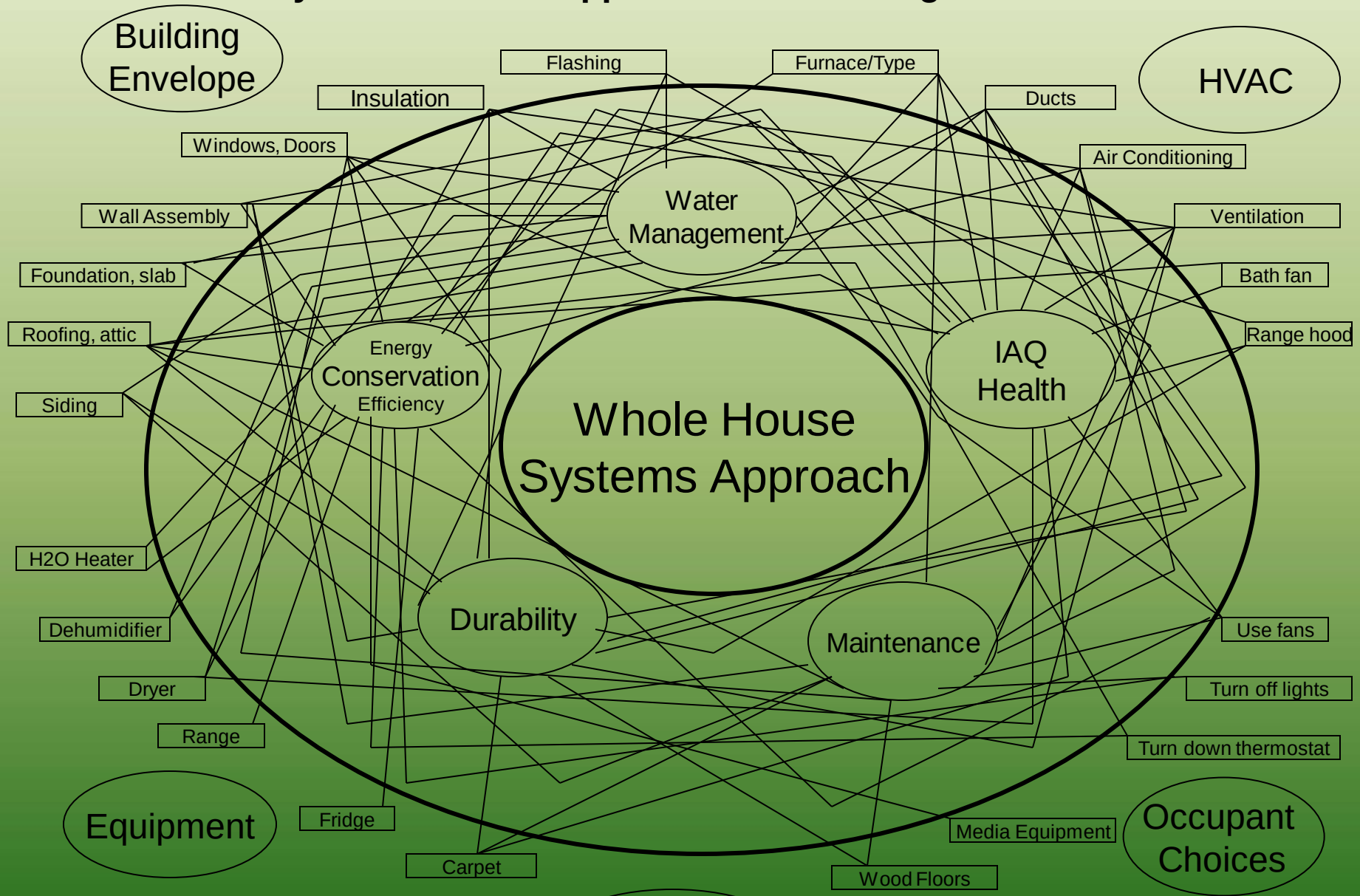
Desired Outcomes

Systems Guided Approach to Achieving Performance



Remodel Changes

Systems Guided Approach to Achieving Performance



Change Impact on Outcomes

PART 1C: THE ORDER MATTERS

- Combustion Safety ⇒ Safe & Healthy
- House Ventilation ⇒ Good Indoor Air
- Moisture Sources ⇒ Moisture Management
- Building Airtightness ⇒ Building Durability
- Increase Insulation ⇒ Energy Efficiency

WHEN THE ORDER MATTERS: TAKE CARE OF PEOPLE

- We must ensure that our homes are safe and restorative!
  - Provide uncompromised combustion safety
  - Provide deliberate pollutant management from both exterior and interior sources
  - Execute sound ventilation and filtration strategies

WHEN THE ORDER MATTERS: TAKE CARE OF BUILDINGS

- We must protect the integrity and longevity of the original building and the resources we have already invested in it.
  - Protect the building from both exterior and interior water
    - both liquid and vapor
  - Provide a warm and dry foundation
  - Make the house as tight as possible
  - Select durable materials and components
  - Make it robust and easy to fix or replace

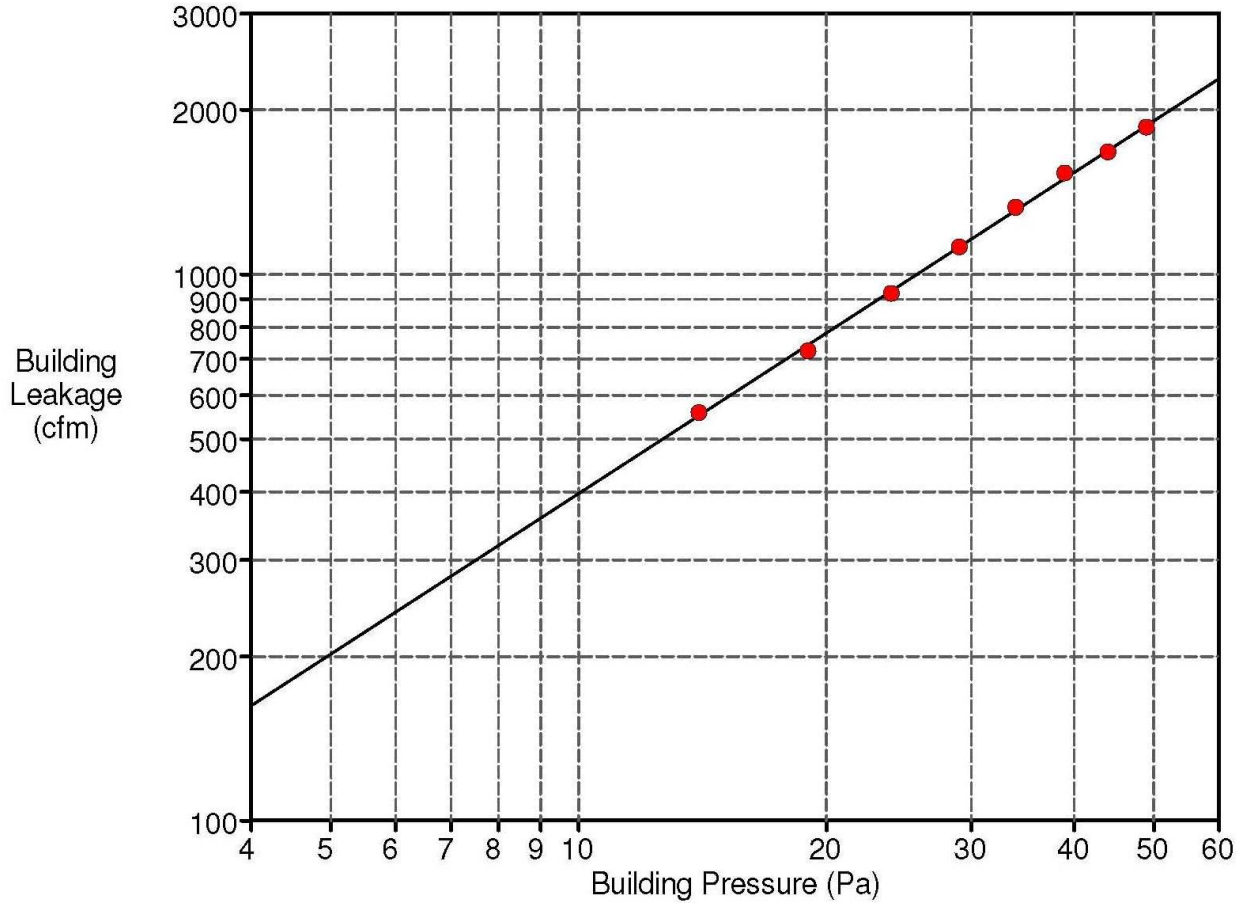
WHEN THE ORDER MATTERS: TAKE CARE OF RESOURCES

- We must be guardians against excessive energy, water, and resource consumption.
  - Improve building thermal integrity
    - optimal insulation
    - airtight construction
    - high-performance windows
  - Install high-efficiency equipment, lights, and appliances
  - Develop a sound water conservation strategy
  - Use low-impact materials, where appropriate

3900 SQ. FT. WALK OUT RAMBLER; MOSTLY COSMETIC REMODEL NEW KITCHEN, BATHS, AND DECK; HAS A SEALED COMBUSTION FURNACE

WALLS OK; VENTED ATTIC W/ 16” OF INSULATION; HAS ICE DAMS
B-VENTED WATER HEATER; NO BATH FANS; PLANS TO ADD KITCHEN HOOD

MULTI-POINT BLOWER DOOR TEST



PART 1D. THE TOP 10 RISKY REMODELS

- Building Enclosure (Envelope)
  - Air sealing
  - Adding/changing wall or attic insulation
  - Finishing/renovating basement spaces
  - Converting/renovating attic spaces
  - Window replacement
  - Exterior grade changes

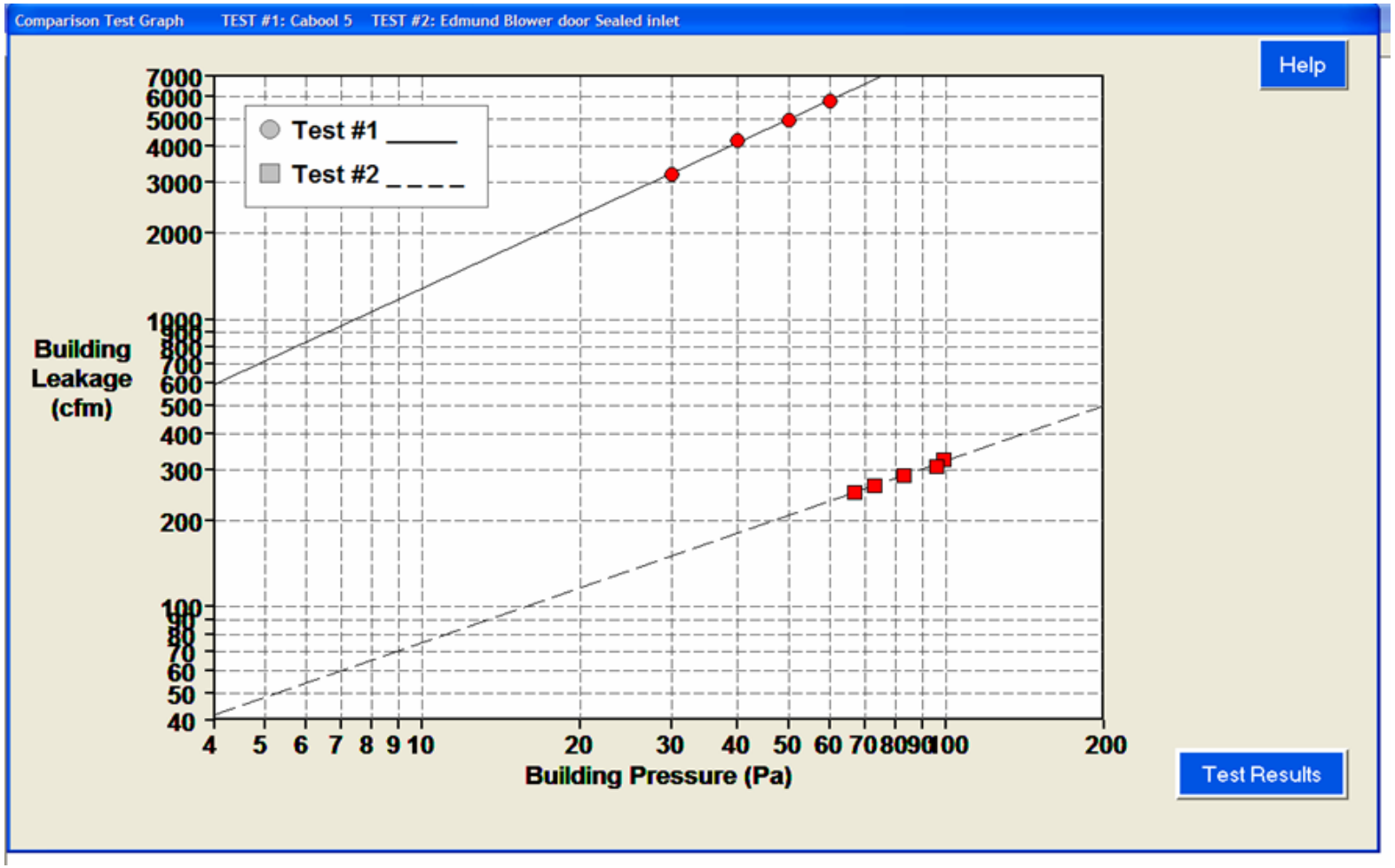
THE TOP 10 RISKY REMODELS

- Mechanical Systems
  - Furnace change out
    - and orphaned water heater
  - Adding exhaust devices
    - especially range hoods, clothes dryers
  - Adding or changing ventilation rates/equipment
  - Duct changes and/or duct sealing

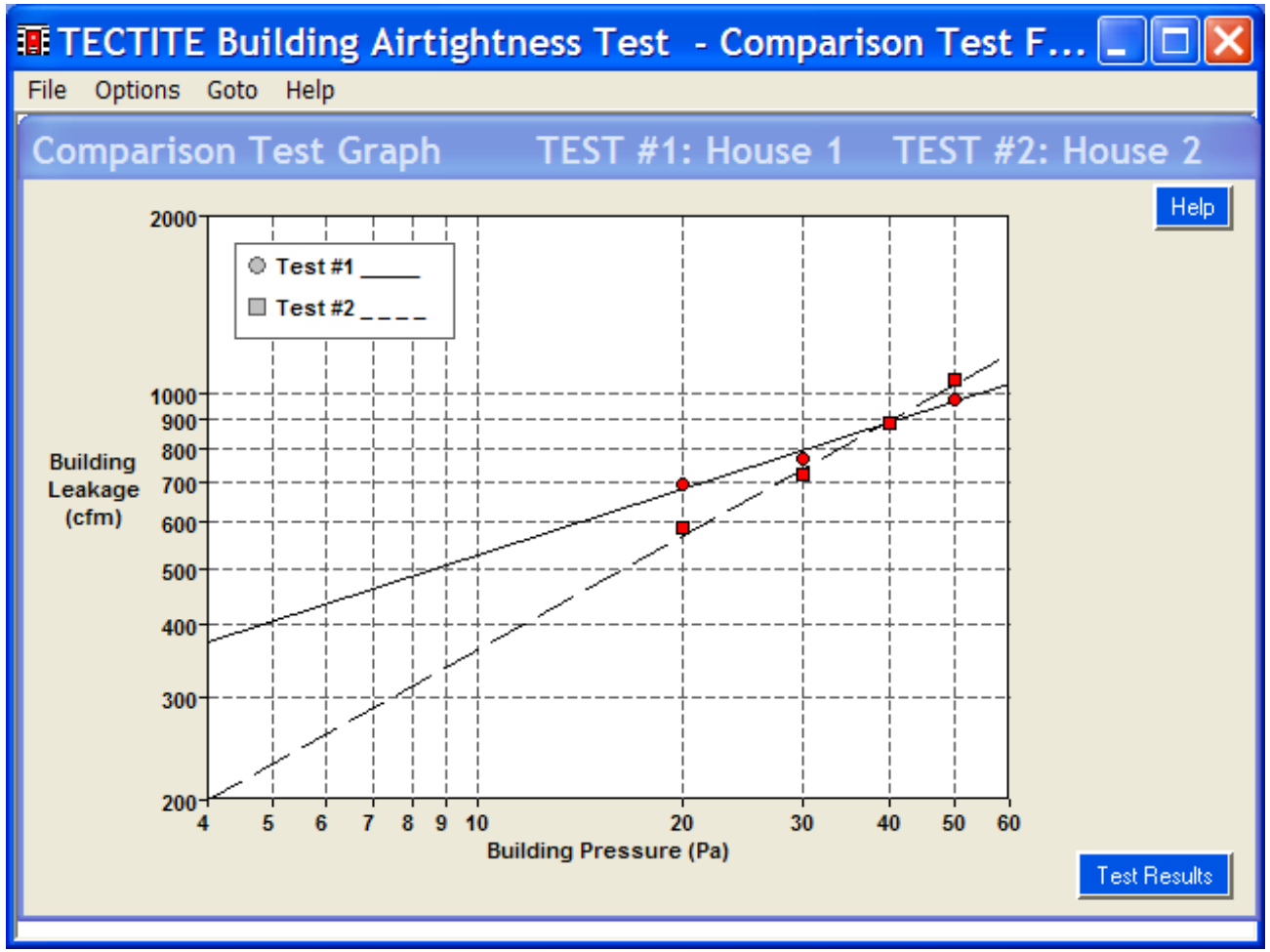
1. INDISCRIMINATE AIR SEALING

- Indiscriminate, inappropriate, or improperly guided air-sealing.
- Why is this risky?

WHAT BALLPARK YOU ARE IN?



BE CAREFUL OF SINGLE POINT TESTS!



GUIDED AIR SEALING – SUMMARY

- Always focus on the big leaks (bypasses) first
- Air sealing should start at top and move down
  - so your house doesn't compete with your chimney
- Air sealing changes everything
  - house air exchange rate (ventilation)
  - house pressure regime (backdrafting, radon)
- Air sealing is a prerequisite to insulation
  - don't remove the heat before removing the moisture
  - may limit future ability to properly air seal

2. ADDING ATTIC OR WALL INSULATION

- Increasing attic or wall insulation without proper air sealing and moisture management.
- Why is this risky?

TOO MUCH MOISTURE; NOT ENOUGH HEAT!

TOO MUCH MOISTURE; NOT ENOUGH HEAT!

DO YOU NEED TO INSPECT INSULATION?

ADDING INSULATION – SUMMARY

- Don’t slow the heat flow until you have slowed the moisture flow
  - especially water intrusion and air leaks
- Adding or changing insulation may make it more difficult or expensive to air seal later.
- For insulation to do its job it must …
  - fill the entire cavity
  - have no air flow through it or around it
  - remain dry

3. FURNACE REPLACEMENT

- Furnace change-out
  - from chimney-vented to power-vented or sealed combustion)
  - with an “orphaned” water heater
- Why is this risky?

AIR FLOW IN CHIMNEYS

- Winter Conditions – 5” to 8” vent to outdoors
  - Off-Cycle (cold chimney)
    - 0 to 50cfm
  - Off-Cycle (warm chimney)
    - 50 to 150 cfm
  - On-Cycle
    - Depending on furnace size = 150 to 600 cfm

FURNACE REPLACEMENT – SUMMARY

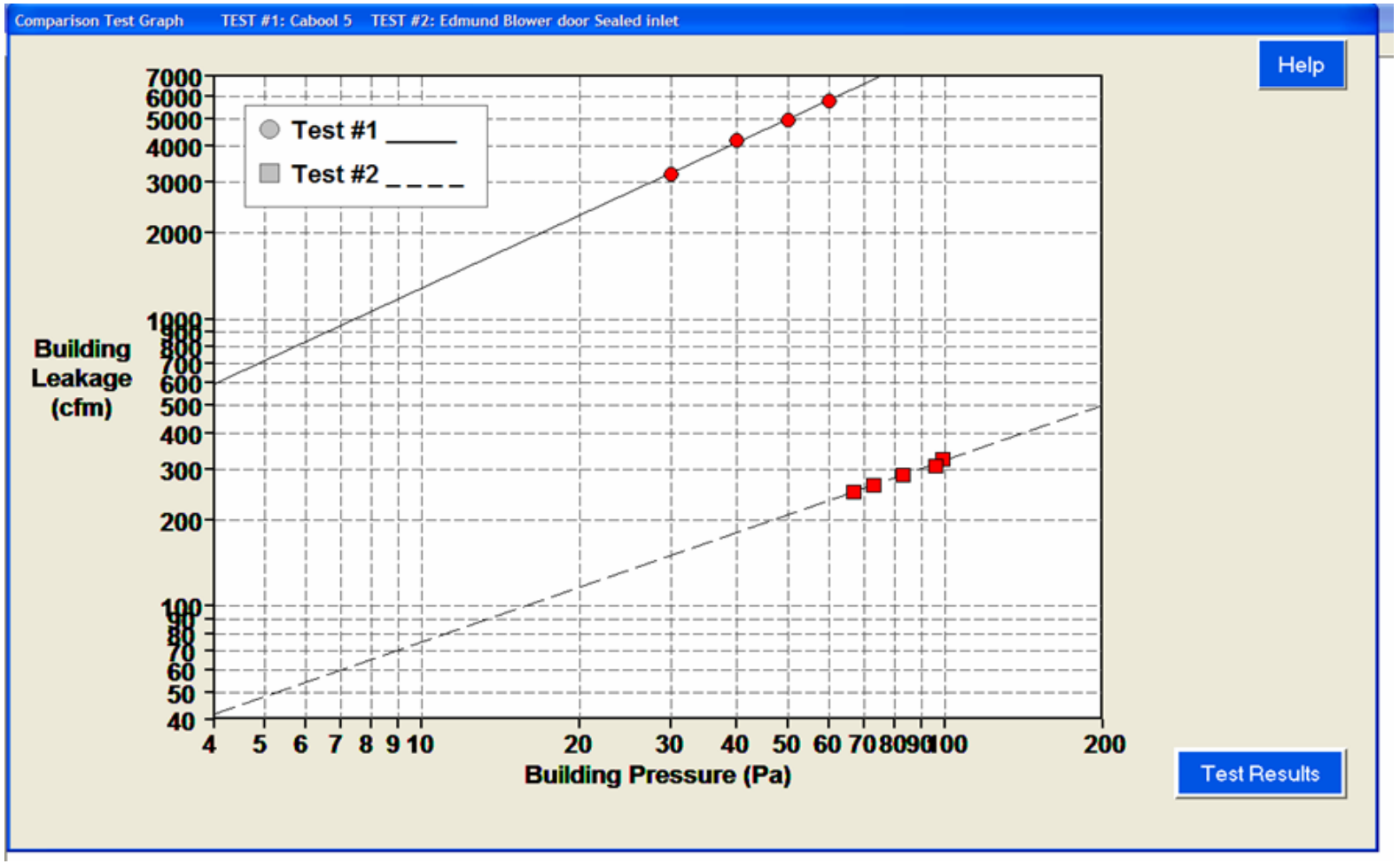
- This is probably the biggest single change you can make in an existing house.
- It changes everything!
  - major change in air exchange rate (esp. mid-winter)
  - major change in house pressures (lowers the NPP)
  - may change duct flows & pressures; zonal pressures
- Don’t orphan the chimney-vented water heater
  - it may not be capable of venting on its own
  - especially as the house gets tighter or exhaust devices are added

4. NEW EXHAUST DEVICES

- Adding large exhausting devices
  - range hoods
  - clothes dryers
  - central vacs
  - ASD (if not done well)

- Why is this risky?

MAKE-UP AIR REQUIREMENTS



MAKE-UP AIR REQUIREMENTS

- Bathroom fan
- Clothes dryer
- Kitchen fan

- 2 at 50 CFM
- 1 at 150 CFM
- 1 at 200 CFM

- Total Exhaust flow = 450 CFM

PASSIVE MAKE-UP AIR OPENING

- Make-up air: CFM provided by smooth duct

Duct Diameter	Atmospheric	Power-vented	Sealed
3 inches	15	35	50
4 inches	30	60	90
5 inches	45	100	140
6 inches	65	140	200
7 inches	85	190	270
8 inches	110 x 1	250 x 2	350
9 inches *	140	320	450 x 1
10 inches	180 x 2	400	570

ADDING EXHAUST DEVICES – SUMMARY

- Can create significant negative pressures
- Can create backdraft conditions for chimney-vented appliances
  - especially as the house gets tighter
- Must provide adequate make-up air
  - passive opening for sealed combustion and small exhaust
  - active make-up air for chimney-vented and large exhaust

46

5. BASEMENT REMODELING

- Finishing or renovating basement space
- Why is this risky?

BASEMENT RENOVATION TOUCHES IT ALL!

- Combustion safety
- Foundation moisture
- Radon (& other soil gases)
- Biologicals (mold, dust mites, etc.)
- Garage gases (if attached)

- And front and center are uncontrolled…
  - negative pressures in basements
  - below grade moisture transport

BASEMENT MOISTURE CHALLENGES

- Foundations get wet from three sides by all four moisture transport mechanisms.
  - bulk water, capillarity, diffusion, and air flow
- Foundations can only dry to the inside.
  - generally by diffusion only
- That means you must keep it dry from all three sides
  - or come up with an approach that promotes inward drying better than outward wetting.

BASEMENT “CLIFF HANGERS”

- Carpet on the slab
- Insulating the walls (from the interior)
- Adding an egress window
- Changing out the furnace
- Changing the ductwork
- Drywalling the ceiling
- Rim (or extended) joists to the garage

BASEMENT REMODELING – SUMMARY

- Just say no!
  - no reverse grading, landscape irrigation, etc.
  - no carpet & no interior wall insulation
  - no chimney-vented combustion
- Just say yes to …
  - ventilation
  - aggressive humidity control (dehumid or AC)
  - radon mitigation
  - paperless drywall (off the floor at least 1”)

6. CONVERTING ATTIC SPACES

- Converting or renovating attic space

- Why is this Risky?

CONVERTING ATTIC SPACES – SUMMARY

- Challenging to light w/o skylight or dormers
- Challenging to air seal thoroughly
  - must get to wall top plates
- Challenging to insulate sufficiently
  - to reduce heat loss
  - to avoid ice dams (minimum of R-40 or 50)
- Challenging to ventilate (if needed)

7. VENTILATION CHANGES

- Changes in ventilation rates and/or equipment
- Why is this risky?

VENTILATION CHANGES – SUMMARY

- Don’t rely on natural infiltration/exfiltration
  - it might not be there when you need it.
- Use current codes and standards as guidance for sizing, distribution, and controls
  - MN Energy Code
  - ASHRAE 62.2
- How will the ventilation system impact …
  - house pressures
  - air temperature & humidity

8. WINDOW REPLACEMENT

- Window replacement without proper air sealing and moisture management
- Why is this risky?

WINDOW REPLACEMENT – SUMMARY

- Be certain the new window will be better than the old one!
- Buy the best window you can afford
  - you only need to recover the incremental costs
- Make certain it is installed properly
  - plumb, level, and square
  - sill is pan flashed to drain out
  - properly flashed on sides and top
  - air sealed

57

9. EXTERIOR GRADE

- Exterior grade changes
  - reverse grade
  - landscape irrigation
  - hose bibs
  - rain gardens
- Why is this risky?

EXTERIOR GRADE – SUMMARY

- Correct grade problems (if possible)
- Minimize surface water quantity & time
  - proper slope = 1’ in first 10 feet
  - gutters with downspouts and extensions
  - avoid damming surface water with sidewalks/edgers
  - avoid trees and bushes adjacent to foundation
- Water storage/recharge must be low and remote
  - ideally below the footing drain level

10. DUCTWORK CHANGES

- Duct changes & duct sealing
- Why is this risky?

DUCTWORK CHANGES – SUMMARY

- Always seal returns (and filter slots) in the CAZ
  - sealing supplies in CAZ can increase negative pressure
- Always try to reduce duct leakage to outside
  - but it can change pressures and will change air exchange
- Always recheck zonal pressures after significant duct modifications.

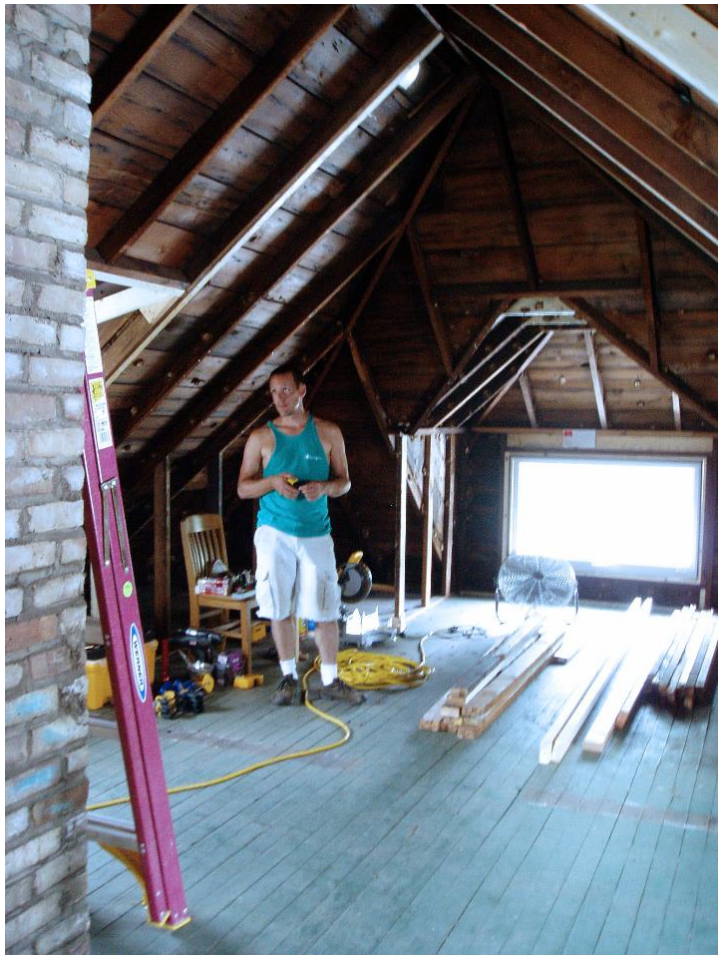
JUST A SIMPLE ATTIC EXPANSION

- Classic Bungalow (1940)
  - Unfinished walk-up attic
  - 1st floor fireplace
  - Fan-assisted furnace
  - Atmospheric water heater
  - No ventilation
- Client wants to finish the attic space for an art studio

JUST A SIMPLE ATTIC EXPANSION

- Client interview/concerns
  - Hard to heat
  - Basement is very cold
  - Frequent ice dams
- Testing Results
  - Moderately tight
    - 1365 cfm @ 50Pa
  - Carbon monoxide ?
  - Basement pressures ?

THIS HOUSE IS AT THE EDGE OF THE CLIFF!



- Can’t begin attic renovation until pre-existing conditions are resolved.
  - Ventilation situation must be fixed.
    - bath fans
    - range hood
  - Stove must be repaired or replaced
  - Fireplace will necessitate a make-up air strategy or change out of water and furnace.
  - Art studio may require additional ventilation.
  - Will need to develop strategy to adequately insulate roof slope.
    - after flashing issues have been addressed

TIME FOR A QUICK PAUSE

- Questions
- Thoughts
- Reflections
- Discussion

PART 2: DEVELOPING A WHOLE BUILDING STRATEGY

- Roles of Testing
- Prescriptive vs. Performance
- Modified Performance Approach

ROLE OF TESTING

- To Test or Not to Test?
  - It clearly adds time, complexity, and cost.
  - But it helps to identify pre-existing conditions, establish a baseline, verify change, and ensure an efficient and safe outcome.

- You can test or you can guess!
  - While those with more experience can guess much better, it is still a guess.

TEST METHODS AND PROTOCOLS

- The Big Questions
  - Is “test in” and “test out” just too expensive?
  - If you test, what do you test?
  - If you test, when do you test?

GOALS OF TESTING

- Do No Harm
  - To satisfy this, must you test in and test out?
- Do the Right Thing
  - Do you need to test in to get the plan right?
  - Do you need to test out to verify the results?
- Improve the Cost Effectiveness of Delivery
  - Can you sell the change without testing?
  - How do you optimize over time without data?

PRESCRIPTIVE VS. PERFORMANCE

- Which should we use?
  - What is the current state of the house?
  - How much is being done?
  - What are the desired outcomes?
    - updated aesthetics
    - better space functionality/utilization
    - general care and maintenance
    - enhanced durability of the structure
    - healthier indoor air
    - improved energy efficiency

PRESCRIPTIVE VS. PERFORMANCE

- Use a prescriptive approach where
  - outcomes are generally cosmetic,
  - system interactions are limited, and
  - heat, air, moisture impacts are likely to be small.
- Use a performance approach where
  - outcomes are performance-oriented
  - systems interactions are likely, and
  - heat, air, moisture impacts are likely to be significant.

A PERFORMANCE-BASED APPROACH

- Begin by “testing in” to …
  - identify any preexisting conditions,
  - establish baseline performance, and
  - develop a house performance assessment.
- Professional judgment is encouraged …
  - don’t bother testing what will be changed out.
    - airtightness prior to a gut rehab doesn’t really help
    - combustion safety testing if the equipment is being replaced is not useful

SYSTEMS-GUIDED, PERFORMANCE-DRIVEN APPROACH

- A 5 Step Approach
  - Test In
  - Plan
  - Verify
  - Test Out
  - Monitor Performance

STEP 1. TEST IN

- “Test In” is always the first step.
  - Identify pre-existing conditions
  - Basis for developing a plan and scopes of work
  - Baseline for evaluating completed work

STEP 2: DEVELOP A PLAN

- Develop a Customized Rehab Plan
  - Each house is different
    - Where it starts => existing conditions
    - Where it ends up => desired outcomes
  - Each action will have different interactions
    - Use the “test in” data to guide the work plan
  - Develop clear work scopes and specs
    - Tell them what will be expected at “test out”
  - This will be your roadmap to successful performance.

STEP 3: FIELD INSPECTION

- Verify Compliance in the Field
  - Proper materials/equipment
    - Is the right stuff on the job site?
  - Proper means and methods
    - Are they following the plan, codes, and standards?
    - Pay close attention to sequence issues
    - Follow the hand-off between multiple contractors
  - Properly document the end product

STEP 4. TEST OUT

- The Job's Not Done Until You "Test Out"
  - Compare results to the initial baseline
  - Compare results to established guidelines and/or criteria set in rehab plan
  - Were performance outcomes met?

STEP 5. FEEDBACK

- Monitor Performance
  - Feedback is a required component for continuous improvement.
  - This is especially critical when we are trying to get maximum results with minimum dollars.
  - It is the only way to increase our effectiveness and efficiency over time.

A MODIFIED PRESCRIPTIVE APPROACH

- Keys
  - Level of Dependency
  - Order Sensitivity
  - Likelihood of Sizable Impact

A MODIFIED PRESCRIPTIVE APPROACH

- Always begin by “testing in” to …
  - identify any preexisting conditions,
  - establish baseline performance, and
  - complete the house performance assessment.

- Then move to a “green light, yellow light, or red light” approach …
  - based on “level of impact”.

A MODIFIED PRESCRIPTIVE APPROACH

- What does “testing in” mean?
  - Establishes the baseline
    - determine current performance levels
    - identify any pre-existing conditions
  - Comprehensive home performance assessment with regard to desired changes
    - visual inspection
    - owner/occupant interviews
    - testing & diagnostics
    - performance assessment report

A MODIFIED PRESCRIPTIVE APPROACH

- What does “level of impact” mean?
  - Systems interactions
    - likelihood of significant connection/interactions
  - Strategic order
    - health and safety
    - durability
    - energy efficiency
  - HAM significance
    - heat flows
    - air flows
    - moisture flows

A MODIFIED PRESCRIPTIVE APPROACH

	Green	Yellow	Red
Test in	X	X	X
Plan			X
Verify		?	X
Test out		X	X
Monitor	?	X	X

GREEN LIGHT – GOOD TO GO!

- Once testing has provided an “all clear” from serious pre-existing conditions, a “green light” can be given for items having low risk due to …
  - limited systems interactions and
  - low heat/air/moisture impacts.

GREEN LIGHT – GOOD TO GO!

- Potential “Green Light” Items
  - Cosmetic changes (interior or exterior finishes)
  - Installing a room air filtration device
  - Change out incandescent lights to CFLs
  - Replace appliances with high efficiency
    - refrigerator or freezer
    - dishwasher or washing machine

YELLOW LIGHT – BE CAREFUL!

- A “yellow light” requires caution for items that might have some risk due to …
  - system interactions below them on the strategic order and/or
  - may have possible heat/air/moisture impacts.
- Possible cautionary steps
  - These may require additional data or “testing out”.
  - It might be a good idea to monitor for unanticipated changes.

YELLOW LIGHT – BE CAREFUL!

- Potential “Yellow Light” Items
  - Adding dehumidification
  - Adding central air filtration
  - Adding ventilation
  - Adding active subslab depressurization (ASD)

RED LIGHT – STOP, LOOK, & LISTEN!

- A “red light” means stop and fully evaluate items with increased risk due to …
  - likely system interactions and
  - significant heat/air/moisture impacts.
- These items will require careful planning, oversight and “testing out”.

RED LIGHT – STOP, LOOK, & LISTEN!

- Potential “Red Light” Items
  - Any item that significantly changes
    - House tightness or pressures
    - Combustion venting
    - Large exhaust (or supply) flows
    - Duct tightness
    - Insulation levels

RED LIGHT – STOP, LOOK, & LISTEN!

- Potential “Red Light” Items
  - Air sealing
  - Adding or changing insulation
  - Furnace change out
  - Window replacement
  - Ductwork changes
  - Adding exhaust equipment (range, dryers, etc.)
  - Adding or modifying ventilation equipment
  - Adding new conditioned area

DO YOU ALWAYS NEED TO TEST IN?

- Modern Two Story (1994)
  - highly insulated
  - airtight construction
  - sealed combustion
  - balanced ventilation
- Client is considering a basement remodel
  - finished walls
  - carpet on slab
  - adding a wood stove

DO YOU ALWAYS NEED TO TEST IN?

- Client interview/concerns
  - Seems like negative pressure
  - Occasional CO Readings
- Testing Results
  - Very tight 360 cfm @ 50Pa
  - Large negative w/ exhaust on
  - Ventilation system runs negative
  - High CO in water heater vent

DO YOU ALWAYS NEED TO TEST IN?

- This house is much closer to the cliff than it looks!
  - pre-existing combustion issue
  - pre-existing ventilation problem
- Walls should be built without adding foundation insulation.
- Due to slab insulation, carpet might work, but should be discouraged.
- Don’t put a wood stove in this house without a make-up air strategy.

MODELS TO MOVE FORWARD

- Weatherization Services Model
- Home Performance Model
  - As lead
  - As requested by:
    - contractor
    - home services provider
- Home Services Provider
    - related-services and/or inspections
- Remodeling Contractor/Subcontractor

A TALE OF TWO APPROACHES

- Model A: An Energy Driven Approach
  - Focused on cost-effective energy savings
  - Spending money to save money

- Model B: Performance Contracting Approach
  - Focused on the homeowner needs and wants
  - Fix their pain; fulfill their desires

A BOLD NEW APPROACH

- What is the homeowner's motivation to do a remodel or retrofit.
  - Environmental
  - Economic
  - Emotional
    - helps fix an identified "pain"
    - helps fulfill a "desire"

PICK YOUR PATHWAY & APPROACH

- Follow the Order (prescription-oriented)
- Test In / Test Out (performance-oriented)
- Modified (or systems-guided) Approach

PART 3: BEST OF NORTHERN*STAR*

BEST OF NORTHERN*STAR*

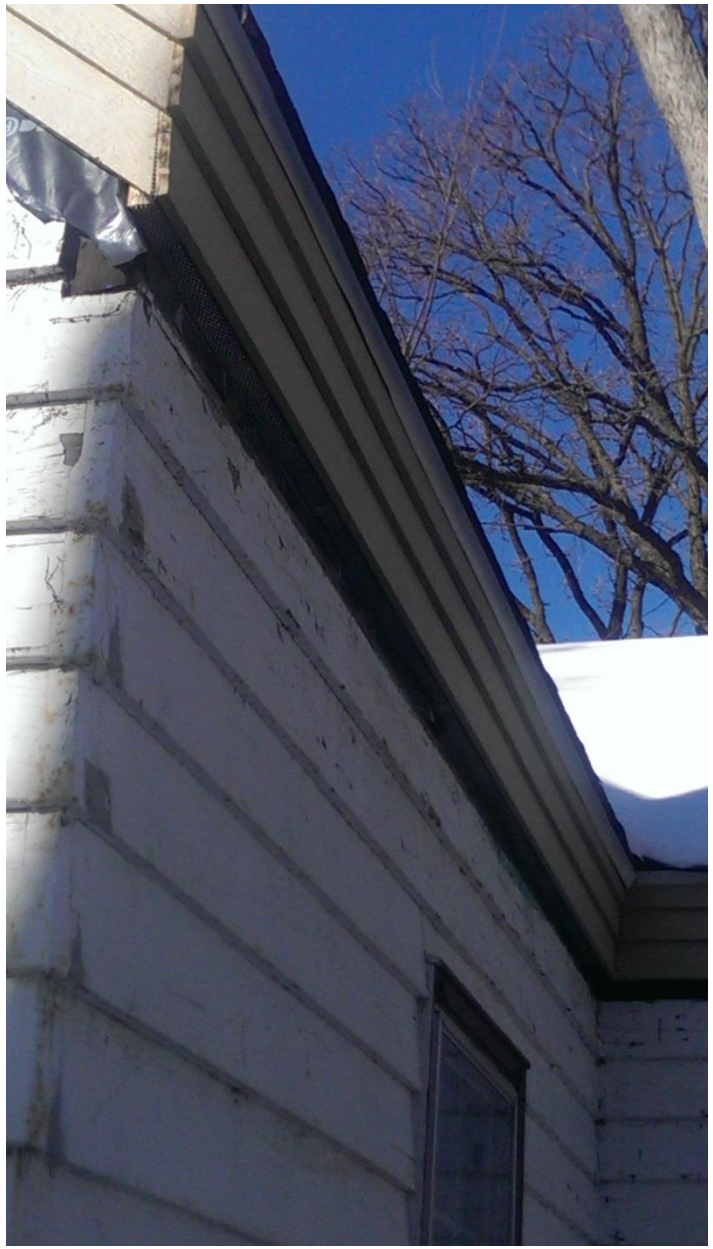
- Work with non-profit, affordable housing provider
  - Identify a classic 1-1/2 story house slated for renovation
- Demonstrate Northern*STAR* “capstone innovations”
  - Excavationless foundation insulation
  - Project Overcoat for the roof
    - and walls, too (if appropriate and applicable)
  - Integrated space and water heating system
    - with source point ventilation
- Facilitate house tours and training opportunities
  - Before, during, and after the installations

“EXCAVATIONLESS” RETROFIT FOUNDATION INSULATION

- Excavate a precision slot
  - plunge, cut, and vacuum
- Use foam forms above grade
  - contain spray foam and provide substrate for finish
- Terminate at the top of the rim
  - more bang for the buck

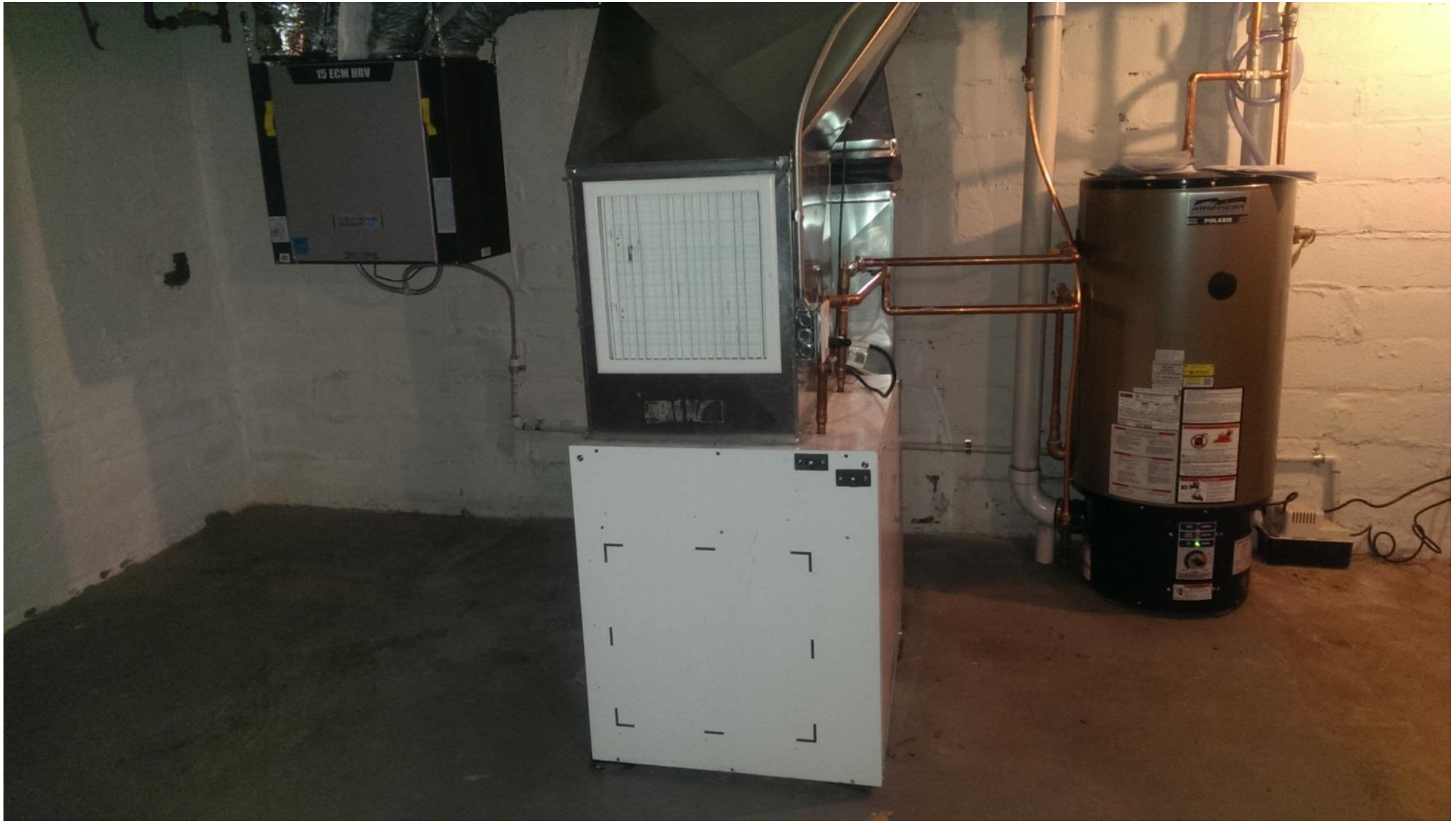
“PROJECT OVERCOAT” RETROFIT CONTROL LAYERS

- Remove existing roofing, overhang and trim
- Add “peel & stick” membrane
  - wrapped over bottom and sides
- Seal top plates and insulate gables
- Add 2 layers of polyiso rigid board foam
  - Staggered in both directions
- 2x4 flat furring with OSB, shingles & ridge vent
  - Build out overhang & finish trim



“COMBI”RETROFIT INTEGRATED SPACE & WATER HEATING

- Remove natural-draft furnace and water heater
  - chimney couldn’t be removed due to fireplace
- Install condensing water heater
- Install ECM fan-coil unit
  - with MERV 10 filter
- Incorporate ventilation system
  - combined source point & general exhaust
  - fresh air to air-handler



TIME TO WRAP!

- Questions
- Thoughts
- Reflections
- Discussion

- Discussion & Questions

Contact Information

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