Successful Retrofits Address All House as a System Processes

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To stay out of trouble
when doing retrofits,
you have to look at
“The House As A System,”
with its interconnected
components and subsystems.

It takes power
to move moisture;
remove the moisture problem
before you save the heat loss.

A retrofit that solves
system problems
will likely save more energy
than one that simply does
mindless conservation.

If you don’t deal with the real-world problems, both you and your client will & pay, & pay & pay.

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The House As A System

The House As A System

- In the real world, as opposed to the lab, everything affects everything else.
- The kitchen island fan can backdraft the flue, and the flue can make a weak fan hood spill when the furnace is running.
- In energy-efficient houses internal gains are often quite significant, but usually ignored when sizing equipment.
- A wet basement can result in condensation and mold growth in upstairs bedroom closets.

Important Interactions

- A tight house with exhaust ventilation
  can be a better chimney than most chimneys.
- Leaky ducting can totally change
  intended air flows to spaces;
  it can also lead to wet walls,
  or spillage from flues.
- Oversized HVAC appliances
  can result in reduced comfort & be too noisy.
- Wind acting on leaky walls or ceilings
  can dramatically change flows into rooms.

Interactions, Cont'd.

- Soil settling next to basements or crawl spaces can result in serious indoor moisture problems.
- Stuffy bedrooms can draw combustion spillage when the wind sucks on open windows.
- Occupants who do not understand can (& often do) make matters worse, if you do not make it right in the first place.
- Leaky ceilings make houses better chimneys.
- Leaky floors over crawl spaces turn the crawl spaces into the air supply.

System Processes in Houses

System Processes In Houses

- Anything that moves air
  moves energy, moisture and pollutants.
- Anything that supplies or uses energy
  can move air, moisture and pollutants.
- The two of these, in combination,
  make everything connected inside the house.
- They also connect the inside to the outside,
  usually when we don’t want that to happen.
- Learn to think like moving power, moving water and moving air; especially moving air!

Moving Air

- Air moves from higher pressure
  to lower pressure,
  no matter what caused the pressure difference.
- In houses that can be wind, stack effect, flues
  and fans (even when we want an other result).
- In a house with a decent HRV (or equivalent)
  there are no good cracks or openings.
- When the house is properly ventilated,
  we know all of the desired air flow paths;
  hidden flow paths are usually dirty ones!

Moving Moisture

- Moisture moves many ways:
  - by gravity (as a liquid);
  - by wicking (often against gravity);
  - with air flows; and,
  - by diffusion.
- In most climates, diffusion is not very important, so vapour retarders may not be needed; air barriers (usually at least two) are always needed in a healthy home.
- Many houses really need a quality dehumidifier!

Ventilation That Works

Ventilation That Works

- In the 19th century ventilating houses was an art; but doing it right took a lot of time and effort.
- We are not willing to learn the craft, but we still need good ventilation (breathing fresh air and removing stale air are both good things).
- Stale air should be removed from all spaces that are occupied by people and pets, & fresh air should be delivered to those spaces.
- Not making that happen is poor workmanship.

Ventilation Processes

- It helps to think about ventilation as four sets of related, important processes:

  * air exchange (inflow and outflow);
  * air distribution (to and from all spaces);
  * air circulation within spaces; and,
  * air treatment.

- All of the above must be done well enough in a healthy home.

Air Exchange

- This is best done
  in a way that ensures balanced flows.
- Use of a Heat Recovery Ventilator (HRV)
  is usually the best and most cost-effective
  way to perform this task
  (include **all** of the costs in your analysis).
- Stale air must be collected and removed.
- Fresher air must be supplied,
  preferably to all healing rooms
  (bedrooms and ‘resting’ rooms).

Air Distribution

- Bring air into one room
  and removing it from just one other room
  is not good enough.
- The approximately-correct amount of air flow
  must get to **all** occupied spaces.
- I have never seen a ‘natural’ flow method
  that really did this well enough.
- Some sort of powered flow system is needed,
  but efficient systems use only a few Watts.
- Remember to provide the return flow paths!

Air Circulation

- Stale air should be removed from all rooms and fresh air must be supplied to all occupied spaces in those rooms.
- Look at the possibility of using distribution to perform this task, using no more power.
- Supplying low on an internal wall and removing high on the same wall may do a good-enough job, most of the time.
- Really good windows do not drive flows the way that poor windows used to do.

Air Treatment

- Air treatment can consist of the following:
  - removal of fine & very-fine dust;
  - supply of moisture in very cold weather;
  - removal of moisture in hot, humid weather;
  - removal of VOC for sensitized occupants.
- Fine and very-fine dust may prove to be an efficient way of delivering toxins to the blood.
- Central humidifiers are almost always so dirty that they make occupants ill.
- Dehumidifiers are needed in some/many climates.

Balancing All Air Flows

Balancing All Air Flows

- Unbalanced air flows are seldom a good idea.
- Supplying more air than is removed,
  from a room or larger space,
  results in pressurization that can drive air
  into leakage paths
  and result in hidden mold during cold weather.
- Exhausting more air than in supplied
  depressurizes spaces, sometime significantly.
- This is bad in any space, if air conditioned,
  and can cause fatalities if done in furnace rooms.

Balancing Using Forced Air

- Few rooms are properly balanced
  when using traditional forced air systems,
  unless:
  * matched supplies and returns are provided;
  * ducting is well-enough sealed: and,
  * registers are not used to unbalance flows.
- While a few Pascals pressure difference
  may not matter much,
  higher differences can lead to serious problems.
- It does not take long to check differences.

Balanced Flows – No Forced Air

- When heating and cooling systems
  do not use forced-air,
  balanced air exchange flows to and from rooms
  requires a well-trained HVAC person.
- Supplies are usually powered,
  but returns seldom are.
- Provide adequate returns,
  but solve the acoustic problems in bedrooms
  (or the occupants will thwart the flows).
- A loud radio in one room is a good test device.

Controlling Moisture Movement

Controlling Moisture Movement

- Controlling moisture movement involves many steps:
  * prevent wet soil next to the foundation;
  * removing excess humidity from indoor air;
  * removing moist air locally;
  * sealing air leaks and controlling pressure differences;
  * keeping the roof leak-free, continuously;
  * providing drainage from all wall cavities (especially behind siding);
  * etc.

Good Soil & Soil Surface Drainage

- Providing good soil surface drainage
  is vital in the long term – wet basements
  and wet crawl spaces make for sick occupants.
- It is not always necessary
  to provide waterproof basements
  if the soil never gets saturated
  right next to the foundation.
- Waterproofing basement and crawl space walls
  may be necessary in some soils
  and where rains can be heavy for days on end.

Keeping Indoor Air Dry Enough

- A high-EF dehumidifier, Energy Star rated,
  is a needed appliance in many regions,
  but maybe only desirable in others.
- When outdoor Dew Point Temperatures (DPTs)
  are much above 10 ºC (50 º F)
  it is usually impossible
  to keep indoor RH low enough
  to avoid dust mite growth in bedding.
- An outdoor DPT above 13 º C (55 º F)
  allows some molds to grow indoors.

Sizing HVAC Systems

Sizing HVAC Systems

- Most existing HVAC systems are oversized; the furnace and air conditioner are oversized, but the ducts are undersized.
- Oversizing equipment **reduces** comfort and undersized ducting increases noise.
- Your energy-efficient retrofit activities will reduce the size of all existing components, even the ducting in most cases.
- Proper resizing will be required and is needed for optimum savings on energy.

Effects of Too-Small Furnaces

- Undersized furnaces are avoided at all costs, but slight oversizing is not deadly.
- If your coldest day is -40 and your indoor is 70F, and you undersize for this condition by 10%, the indoor temperature will drift on down towards 59 F, if there are no internal gains.
- In energy-efficient houses, the time to cool is measured in many hours, usually 10's of hours.
- Internal gains often overcome the drop.

Effects of Oversizing

- Oversized furnaces and air conditioners
  do not run long enough to become efficient.
- The furnace also delivers air
  that is cooler than it could be,
  if the run time increased.
- The air conditioner removes less moisture
  than it will when properly sized;
  dehumidification is more important
  than reduced air temperature
  in determining comfort in hot, muggy weather.

Insulation That Works

Insulation That Works

- Installing insulation badly
  may not save much energy!
- Most insulation relies on keeping included air
  virtually motionless and keeping insulation dry.
- Most fibrous insulation is installed
  so that it is subject to air flow-through
  at rates that decrease its effectiveness.
- Providing an effective air barrier
  both inside and outside of insulation
  it not just a good idea; it is a vital requirement.

Wind Barriers

- One of two air barriers that is needed
  in almost all successful, energy-efficient houses,
  is a wind barrier that is outside the insulation.
- This barrier should really be rigid enough
  to resist movement in blustery wind conditions.
- Well-adhered Tyvek, or equivalent,
  will do a fair job for some length of time;
  if it is **well** fastened down, it will work better.
- It is most important at corners
  and should cover the headers.

Indoor Air Barriers

- Keeping indoor air moisture out of insulation is one requirement of the indoor air barrier.
- Keeping pollutants that exist, or occur over time, within the insulation layer is the second reason for air barriers indoors.
- A second air barrier helps prevent air flow through the insulation to the indoors, or to the outdoors (with wind barrier flaws).
- You cannot have too many air barriers, as long as they are not vapor retarders as well.

Inspection/Verification

Inspection / Verification

- A retrofit isn't OK because you say so;
  it is OK because you have shown that it is!
- Verification that each step was well done
  can be the best verification.
- An inspection of critical steps
  is almost as good;
  the inspector should really be independent.
- Will your crew do better work
  if they know that you take pictures often,
  and also have an inspection performed?

The ?Costs? Of Inspections

- Do inspections/verification cost or pay you?; the answer is not as simple as you think!
- The cost of redoing things not done well requires you and your best workers who could be doing the next job well instead.
- It does not take much time on recalls to eat up the ?savings? of doing things poorly.
- Selling costs, when you do good work, and your clients can confirm that, is a much shorter (and less expensive) process.

What to Verify/Inspect

- Verify envelope air tightness every time.
- Verify soil surface slopes all around the house (after settling or after compacting).
- Verify temperature rise during heating, at the furnace and at the registers.
- Verify temperature drop during cooling (at the registers, not just at the air handler).
- Only omit inspections that you **know** do not have to be done (no guessing allowed).

Conclusions

Conclusions

- In a house,
  all performance depends on everything else.
- Anything that depends on energy flows (power)
  will influence all other processes
  that they are connected with, directly or not.
- Anything that involves air movement
  can move a lot of:
  energy;
  moisture; and,
  pollutant.

Conclusions, Cont'd

- If you want to do good work,
  and have work during slow times,
  make sure that you know what has to be done,
  then do it well.
- You cannot understand what has to be done
  until you understand interactions
  of power flows, air flows, moisture movement
  and pollutant flows.
- You have done a good job
  when you have proven that you have done so.

Recommendations

Recommendations

- Learn how to do the job better
  than anyone else.
- Especially learn how everything is linked.
- Verify that you have done a good job,
  and give that proof to your clients.
- Use that trail of proof
  to convince your workers/trades
  that you believe the proof is in the pudding.
- Assemble a list of jobs well done.

Recommendations, Cont'd

- Learn from mistakes, by yourself,
  and by your workers/trades.
- Find a way to avoid making the same mistakes
  (there will usually be new ones to learn from).
- Sell your work for all that it is worth.
- Explain why you do things the better way,
  to your workers and trades,
  as well as your next clients.
- Know that you are the best,
  because you can prove it.

Jim H. White

- Jim is a scientist
  trained in an engineering faculty,
  to move new science into practice.
- He did the system design of the Canadarm
  on the US Space Shuttle.
- He invented the term “The House As A System”
- He started the investigation of why
  some houses make occupants ill (at CMHC in 1981).
- He did original research into how much power
  and energy housing processes really need.
- He owns System Science Consulting.