When we build, let us think that we build forever.

“Let it not be for present delight nor for present use alone. Let it be such work as our descendants will thank us for; and let us think, as we lay stone on stone, that a time is to come when those stones will be held sacred because our hands have touched them, and that people will say, as they look upon the labor and wrought substance of them,

“See! This our parents did for us.”

John Ruskin 1819-1900
Which House Would You Choose?

The fact is that People buying houses don't know that they want to talk about performance

- Largest Purchase
- Largest Investment
- Least knowledge
How Have Houses Changed?

Why is this a 100 year old house?

- Drafty, uncomfortable, yet very durable houses
  - Why?
- Expectation?
Building a House Today

- What have we done to houses to meet there expectations?
  - Thermal Insulation
  - Tighter Building Envelopes
  - Heating & Cooling Systems
- Yet are our Houses are not
  - Comfortable
  - Durable
  - Safe
  - Energy Efficiency
  - Environmental
- How can we meet the Expectation?
  - Applied Building Science and systems thinking

The House as a System

(EEBA Builders Guide)  www.eeba.org

“Residential Construction is a complex operation including thousands of processes by dozens of industries, bringing together hundreds of components and sub-systems into a house.”
Systems Integration + Applied Building Science

Synergy

- Two or more things working together to achieve something they could not achieve alone
  - Man / woman
  - Democrats / Republicans
  - Aerodynamics / engine
  - Insulation / air barrier

- Look for the impact

- Logic of the process

People Factors

- What do they care about?
  - Aesthetics

- Expectations
  - Safety
  - Energy Efficiency
  - Durability
  - Sustainability
  - Comfort

- People = Need for Systems Thinking

  How to take the people out of the equation
How does air move in a house?
Freight Train

Moisture

**Moisture = #1 enemy of most building materials**

Small amount of repeated wetting can lead to:
- Reduced R-value
- Mold, mildew
- Deterioration, rot

**Moisture sources**
- Bulk water
- Vapor diffusion
- Air movement

Courtesy of DOW Building Materials
Stack Effect in a Two Story House

Stack Effect

Ice Dam at Work

- Neutral Pressure

meltwater

snow

interior heat

WIND

+ -

+ -
Can a House Be Too Tight?

**NO!**

- Wrong question
- Control airflow
- In order to control the air

Real question ..........

- Can houses be under-ventilated?

**YES!**

*Build Tight and Ventilate Right*

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**Ventilation: M1507.1 General**

- Where local exhaust or whole-house mechanical ventilation is provided, the equipment shall be designed in accordance with this section

**ASHRAE Standard 62.2 – 2010**

- Both Whole House Controlled Mechanical Ventilation and Spot ventilation standard
- This standard applies to spaces intended for human occupancy within single-family houses and multifamily structures of three stories or fewer above grade, including manufactured and modular houses
Thermal Envelope
Basic Building Science

- Basic Building Science
  - Thermal Flow
    - Define the thermal boundary
    - How systems work to control Conditioned air
      - Heat and Moisture

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Insulation

- Insulation traps pockets of air
- Stagnate Air Pockets create the R-value

Air Barrier

- Stopping the movement of air from scrubbing away the stagnate air pocket
- Now it works
Vapor Diffusion a Slow Small Process

http://www.efficientwindows.org

From EEBA Builder's Guide to Cold Climates by Joseph Lstiburek
The Problem with Air - the 4 M’s

- Much
- More
- Moisture
- Movement

32 Square feet

From EEBA Builder’s Guide to Cold Climates by Joseph Lstiburek

Micro Climates

- Controlled environment
  - Consistent Comfort
  - Temperature
  - Humidity
  - Air Quality

- Predictability / Control
  - Tighter
  - Insulation
  - Mechanical Systems
  - Ventilation
Quick Review System Effect

Supply side leak in attic
+ where - where?

Return side leak in attic
+ where - where?
How Manual J Works

- Manual J describes every component of the thermal envelope
- Determines the Btu per hour of heat loss and heat gain through the envelope at specific design temperatures
- End result – the heating and cooling load for the house
- Room by Room load

BTU per hour of heat loss or heat gain through an assembly $U \times A \times \Delta T = Q(\text{Btu})$

- U-value x Sqft x Delta T = Btu per hours

Example
- 500 sqft
- R-19
- Indoor temp at 70° and
- Outdoor temp at 3°

$.053 \times 500 \times 67 = 17,755 \text{ Btu per hours}$
Manual D

- Determine how much flow is needed to achieve comfort in each room based on distributing the load to each room in the house.

Duct Design

- Determine how to design, size, and run the duct system to ensure the proper flow and distribution of the Btu’s.
Tunnel House
8/10/2013

House Built in 2004
• Avg. Energy Consumption per person 343 MMbtus
• 13,800 kWh of electricity use per year
• Avg. fridge size 20 cubic feet – 420 kWh/yr

House Built in 1970
• Avg. Energy Consumption per person 331 MMbtus
• 6300 kWh of electricity use per year
• Average fridge size 15 cubic feet – 1700 kWh/yr

House built in 1950
• Avg. Energy Consumption per person 227 MMbtus
• 2200 kWh of electricity use per year
• Avg. Fridge size 9 cubic feet – 360 kWh/yr

Energy
ENERGY STAR
What is Energy Star?

- Energy Star is a joint program of the EPA and the DOE helping us all save money and protect the environment through energy efficient products and practices.

Building a House.....
System Harmony is the Goal

People

Systems

Structure

Must operate in Harmony in a particular environment

Climate Zones

All of Alaska is Zone 7

Southwest New Mexico, West Texas, and Florida

Lake Erie, Lake Michigan, Great Lakes, and Hudson Bay

Northwest Arctic, Yukon, Northwest Territories, and Alaska (except for Bering Island)

Zone 1 includes:

Bolivia, Brazil, and the West Indies

Warm - North of White Line

Dry (B)

Moist (A)
Fundamental Questions

Is It There? Does It Work?

Is It There? Does It Work?
Combustion safety
Water Efficiency

Water Conservation and Energy Efficiency

look for

Welcome

EAT YOUR VEGETABLES
PV is the Dessert

Applied Building Science & Systems Thinking

- Defensible space
- Conditioned attics vs. attic ventilation
- Home sprinkler systems
- Building material choices
Thank you!

Robby@nrglogic.com
www.nrglogic.com

720-838-0677