Building the High Performance House

Beyond Code Programs That Give You and Your Customer The Edge

- In accordance with the Department of Labor and Industry’s statute 326.0981, Subd. 11,

- “This educational offering is recognized by the Minnesota Department of Labor and Industry as satisfying **1.5 hours** of credit toward **Building Officials and Residential Contractors** continuing education requirements.”

- For additional continuing education approvals, please see your credit tracking card.

Learning Objectives

1. Using experience from presenters and the audience, define what constitutes a standard code house compared with a house that goes beyond code.
2. Attendees will gain a good understanding of the content of programs presented.
3. Understand how the programs differ.
4. Enhance critical thinking skills to allow builders to determine which programs will further their goals.
5. Understand what overall components are necessary to achieve a high performance home.
6. Understand the overall importance of building high performance and low energy use homes.
7. Attendees will be able to define for themselves the five most important items that must be done to build a very efficient house.
8. Attendees will be able to identify upgrades that are consistent with building science principles.

Presenters

- Marilou Cheple, Moderator
  - University of Minnesota Cold Climate Housing
- Rachel Wagner
  - Wagner Zaun Architecture
- Michael Resech
  - Residential Science Resources
- Pat Huelman
  - University of Minnesota Cold Climate Housing

Part One
Defining the High Performance House

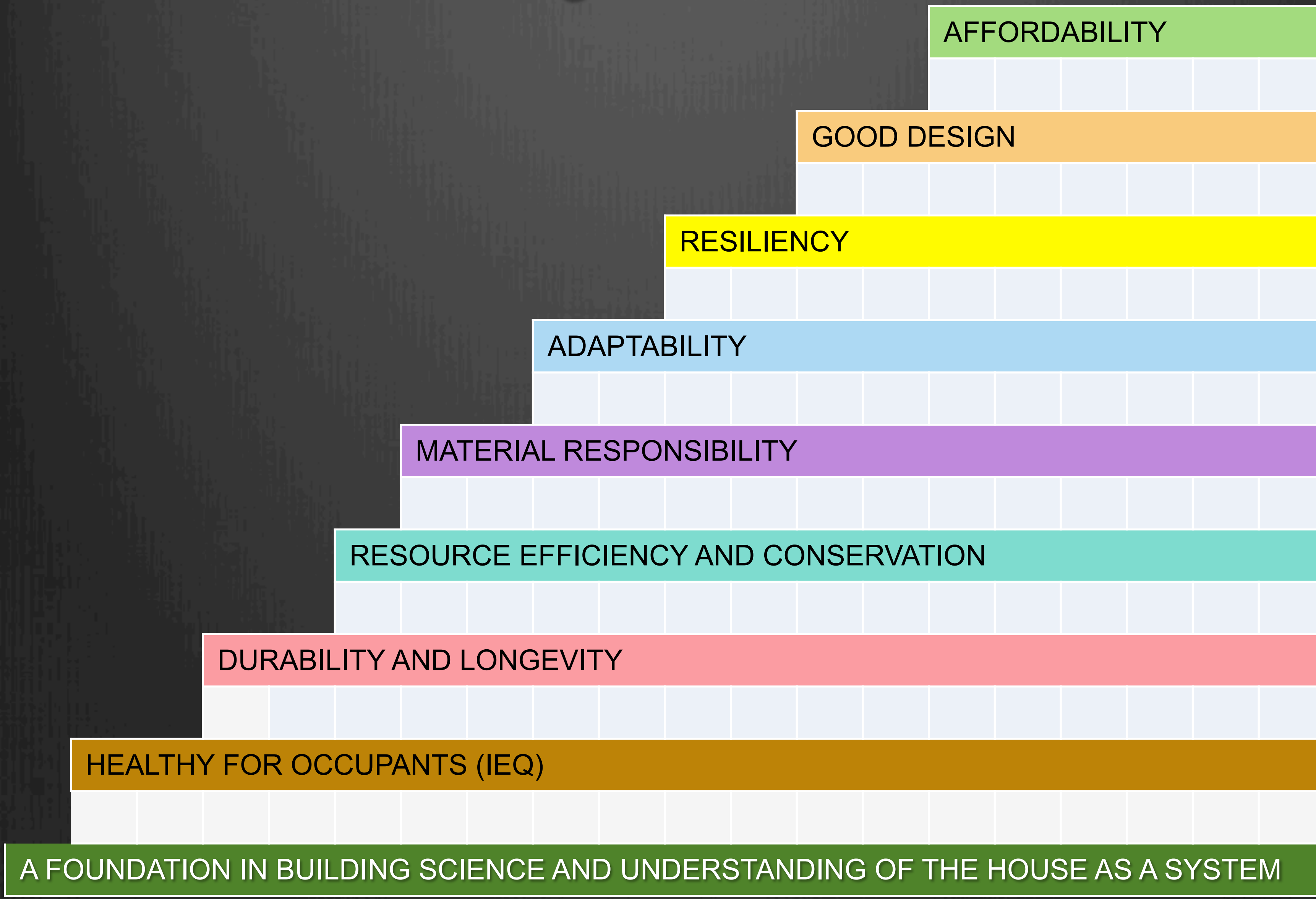
What is "Building Performance?"

The Response/Effects of Forces Acting Upon a Building

Efficacy of Operation
Efficiency of Operation
Functionality
Effect on Occupants

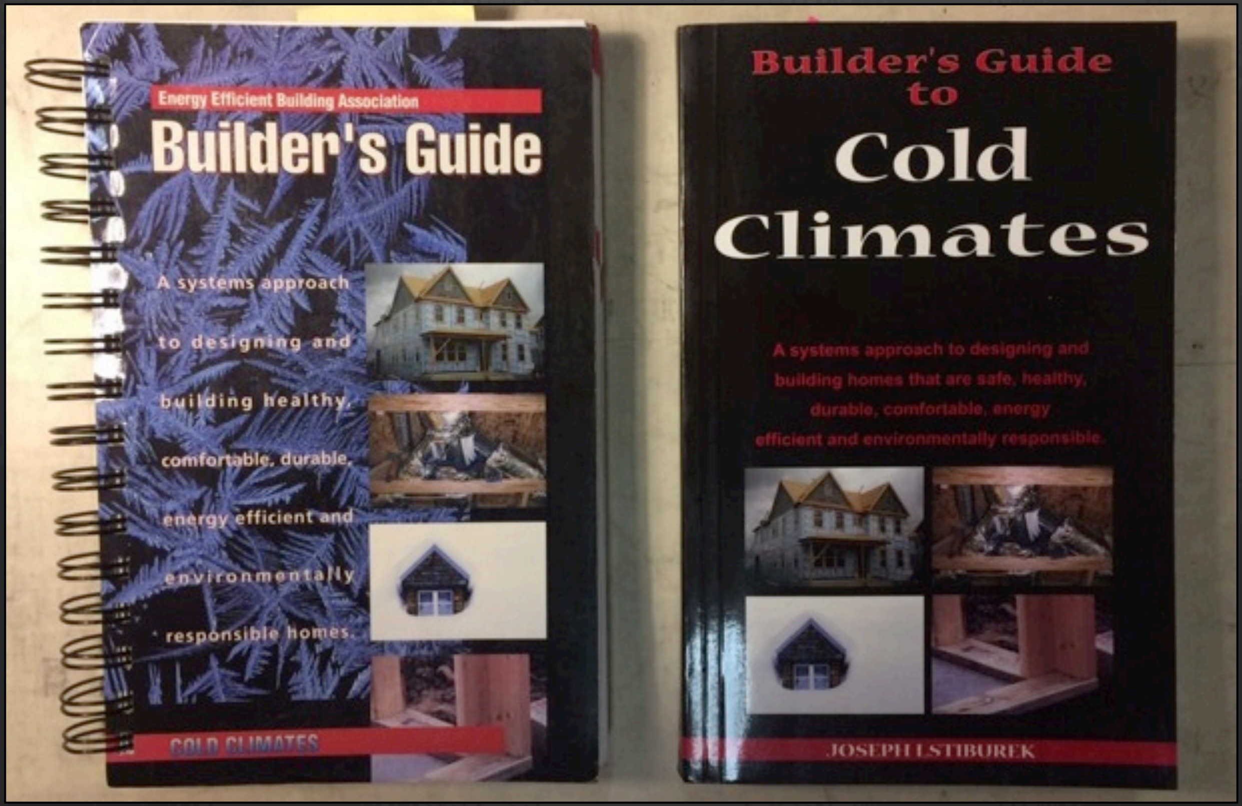
Image from wbdg.org

What Makes a High Performance House?



Building Science and the "House as a System"

The foundations of high performance.



Building Science Defined

Building science is a field of knowledge that draws upon physics, chemistry, engineering, architecture, and the life sciences.

Understanding the physical behavior of the building as a system and how this impacts energy efficiency, durability, comfort and indoor air quality is essential to innovating high-performance buildings.

Modern building science attempts to work with models of the *building as a system*, and to apply empirical techniques to the effective solution of design problems.

- From Whole Building Design Guide wbdg.org

These Things Matter (a lot)

- Moisture Flow
  - Water
  - Vapor
- Air Flow
- Heat Flow

Not surprisingly, these things often work together.

Moisture Management

- Assembles get wet.
- Moisture comes from the interior and the exterior.
- Too much accumulated moisture can cause damage.
- Strategies to minimize the risk of moisture damage:
    - Control of moisture entry
    - Control of moisture accumulation
    - Removal of moisture
- Assemblies should be able to remove the moisture,
    - By draining
    - Or by drying.

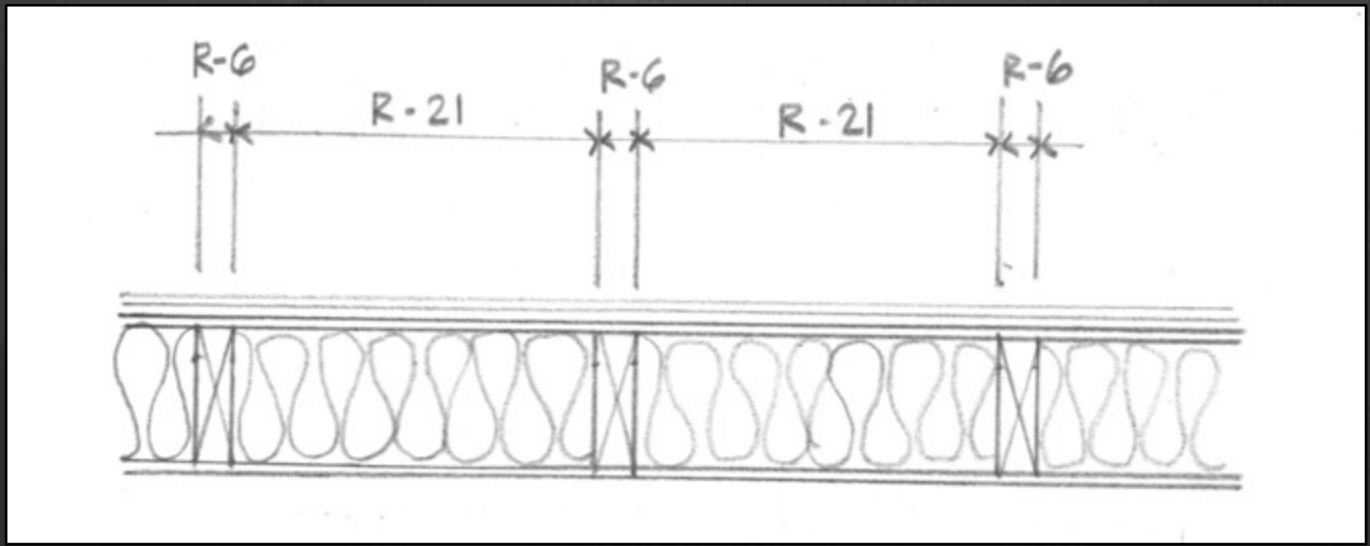
Paraphrased from the Builder's Guide to Cold Climates by Joe Lstiburek

Managing Air Flow

Air Barrier systems should be:

- Impermeable to air flow
- Continuous over the entire building enclosure
- Able to withstand the forces that may act on them during and after construction
- *Durable over the expected lifetime of the building.*

Heat Flow and Thermal Bridges



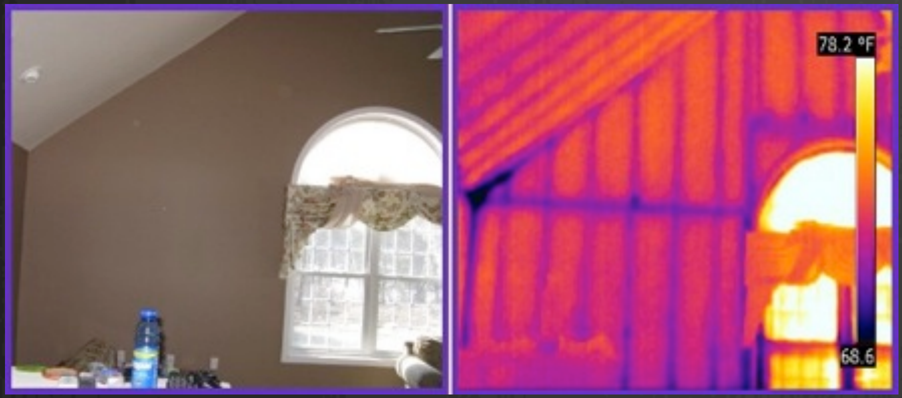


Image from homenergypros.lbl.gov

"Warm moves toward cold." The capacity of thermal Resistance of a material is expressed in R-value. Higher R-value indicates more Resistance to heat flow.

Thermal Bridges Matter

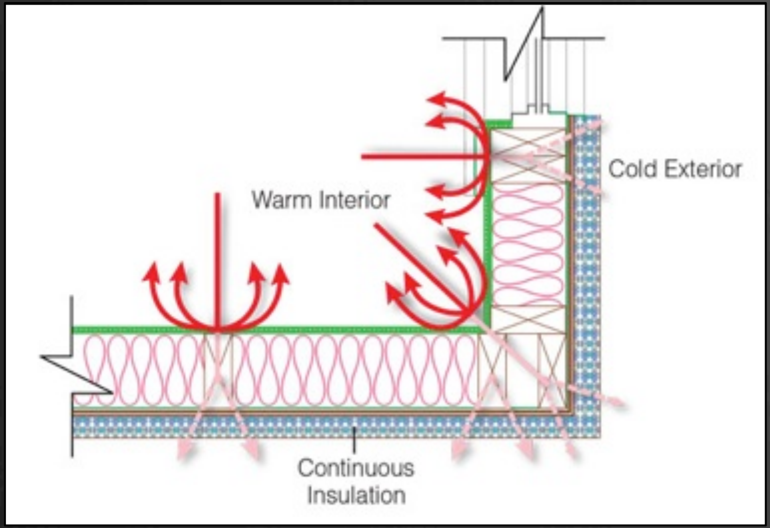


Photo: Dryvit.com

2 x 6 wall with only R-21 cavity insulation has a real R-value of about R-17. Add R-10 c.i. and the wall R-value is nearly R-29

Spray foam cavity insulation does not make a high performance house.

2 x 6 walls with 4” of SPF R-6/inch still have a real wall R-value of only R-18.

The extra money is better spent on continuous exterior insulation and better air sealing.

Failure to manage the flows will reduce building performance.

- If you don’t manage bulk water or water vapor and the assembly fails, then other High Performance measures are worthless.
- If you don’t manage air, you can end up with moisture transport.
- Air leakage also increases heat loss.
- Thermal bridges can create cold spots which in turn allow condensation to form.

The "House as a System"

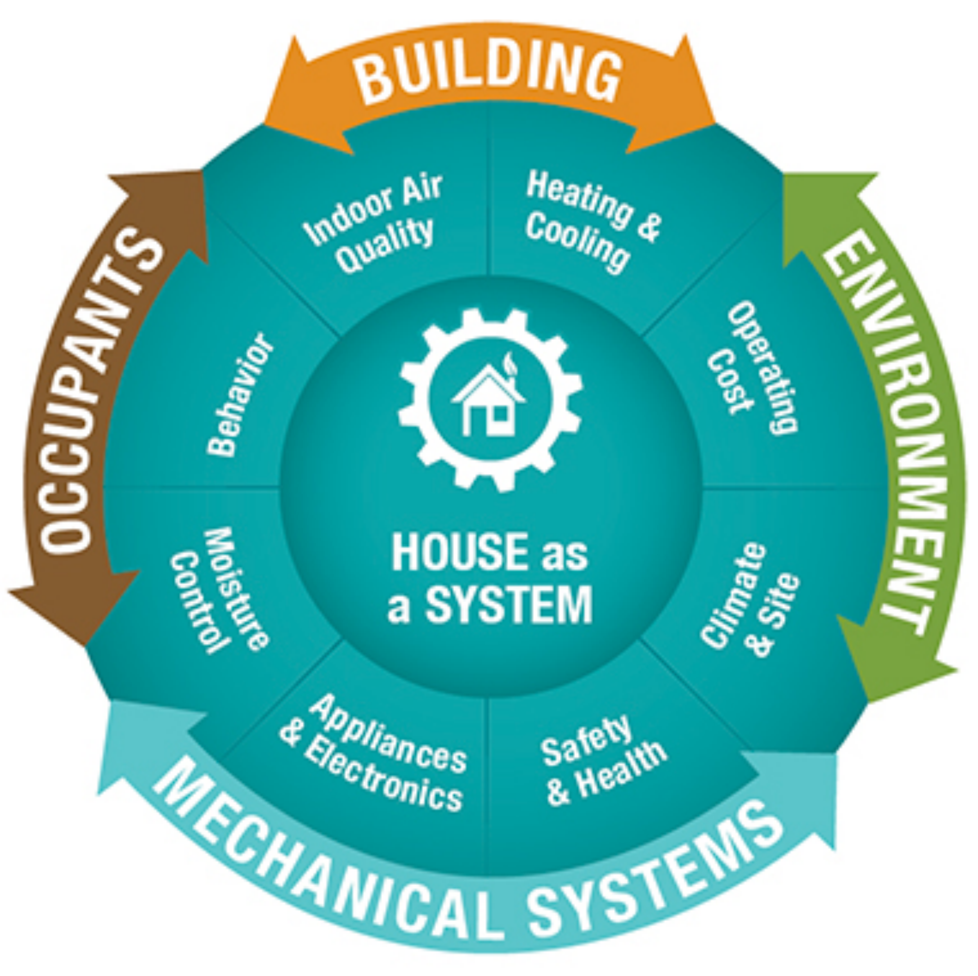


Image: pinterest.com

Integrated systems, not segregated systems.
Integrated thinking, not segregated thinking.

Only one of these is holistic

Integrated Thinking

Image from openclipart.org

Segregated Thinking

Image from pixabay.com

Occupant Health/IEQ

- Moisture Management
- Fresh Air
- Thermal Comfort
- Freedom from Pollutants
- Freedom from Allergens
- Understandable Operation

Will it be safe?

Have a checklist for occupant health and safety issues, and understand when one component can affect another.

Common things to consider:

Radon

CO_2

CO

VOCs

Dust mites

Mold

Mildew

Durability

- Do it right the first time.
- Manage water.
- Use materials appropriately.
- Make it fixable.
- Build so the things that wear out first can be replaced without messing up the other stuff.

Resource Efficiency and Conservation

High Performance Expectations

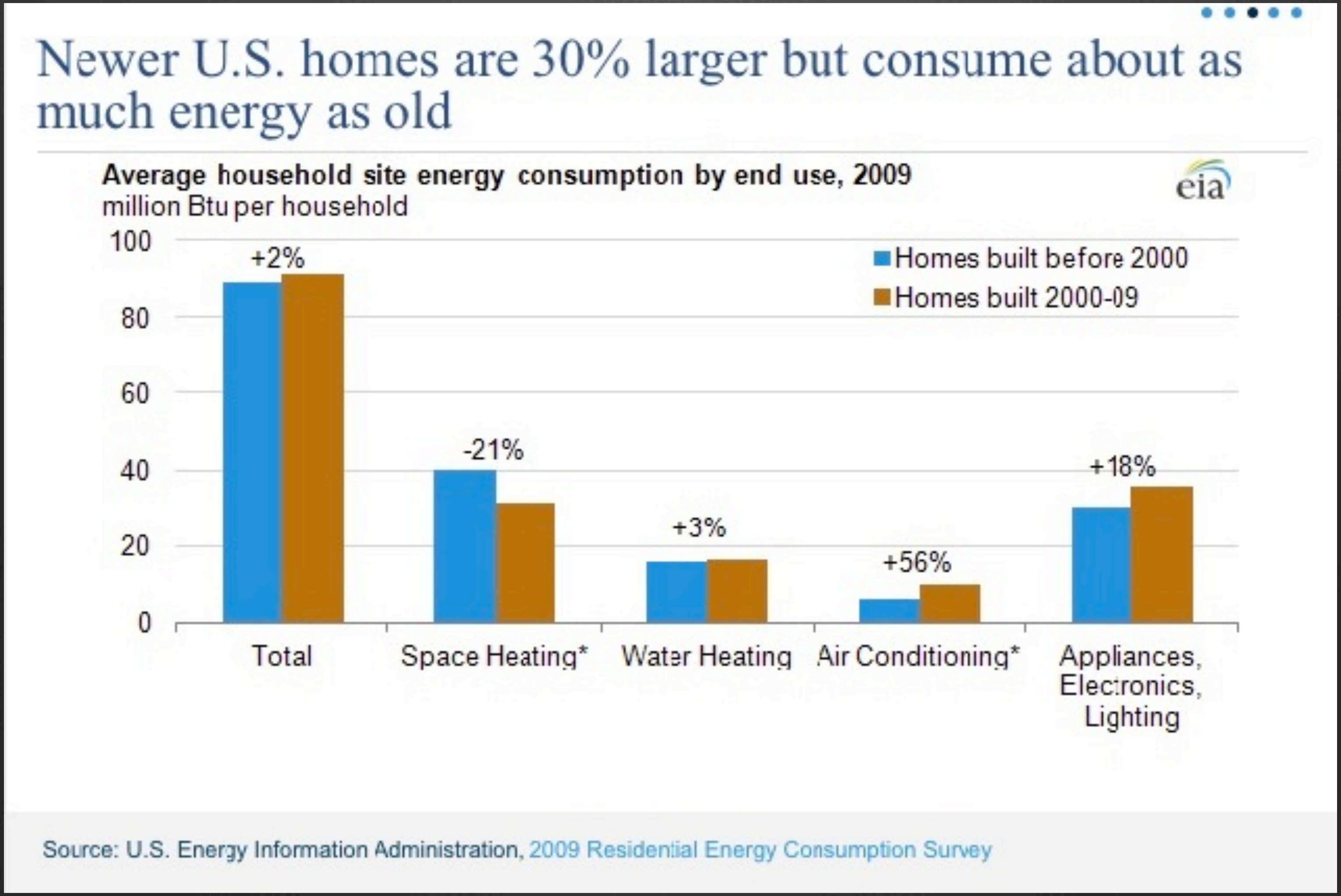
- Energy conserving building enclosure
- Low space conditioning loads
- Efficient, right sized HVAC equipment
- Renewable energy systems or renewable energy-ready
- "Net zero possible"
- Water conserving
- Efficient Appliances, lighting and controls

Resource Efficiency and Conservation

Side Note: Expectations and Trends

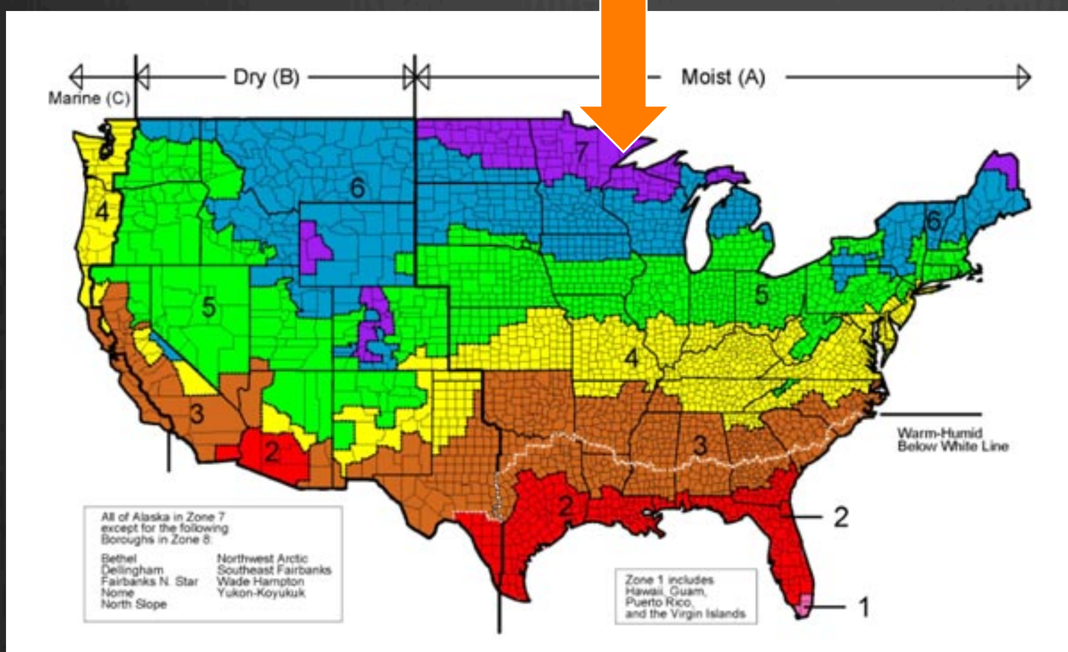
- Size of home
- Occupancy of home
- Multi-family vs single family
- Master Suite and “en suite” bathrooms
- Fancy kitchens
- Technology
- Comfort Criteria

"Average" energy use, 2009



Region plays a role.

In 2009, the average Wisconsin household used 103 million Btu of energy per home, 15% more than the U.S. average. Average MN home used 113 million Btus of energy. Source EIA



AVERAGE SQUARE FOOTAGE

US	1,971
ENC	2,251
WI	2,605

Defining Low Energy

Definitions Vary. (More discussion later.)

Energy Star:15 – 30% less energy than a “typical new home”

An “average” new Home in MN or WI (about 2600 ft2):

Total energy used: 108 MMBtu/year	(41.5 kBtu/ft2)
15% Reduction Goal = 91.8 MMBtu	(35.3 kBtu/ft2)
30% Reduction Goal = 75.6 MMBtu	(29 kBtu/ft2)
50% Reduction Goal = 54 MMBtu	(20.8 kBtu/ft2)
70% Reduction Goal = 32.4 MMBtu	(12.5 kBtu/ft2)

Real Energy Use

Esko Farmhouse/Built 2009
2 stories + basement
2690 ft2 conditioned space

4 bedroom, 2 bath

Total annual energy = 47 MMBtu*

or 17.5 kBtu/ft2/yr

Norwood House/Built 2014
Split-level
1500 ft2 conditioned space

3 bedroom, 2 bath

Total annual energy = 40.3 MMBtu*

or 26.9 kBtu/ft2/yr

Where is the energy consumed?

To reduce all building energy use significantly, start with the heating energy, but don’t stop there.

In New Homes heating energy typically accounts for 30-40% of all energy usage.

Source: EIA

Defining Low Heating Energy

(Building on work by Energy Analyst Andrew Shapiro)

Peak Design Heating Loads:

Energy Efficient Home	30,000 – 50,000 Btu/hr
	15 - 20 Btu/hr/ft2
Micro Load Home	20,000 – 30,000 Btu/hr
	10 - 15 Btu/hr/ft2
Ultra Low Energy Home	6,000 – 20,000 Btu/hr
	3 – 8 Btu/hr/ft2

Enclosure for Reducing Heating Loads

	Ultra Low Energy	Micro-Load	2015 Code
Under Slab	40	27	10
Above grade walls	34 cav/19 c.i.	34 cav/11 c.i.	21 cav
Windows (U)	.18	.23	0.3
Roof	86	70	49
ACH50	.4	.7	3
Peak Heating Load	13,500 Btu/hr	17,700 Btu/hr	33,900 Btu/hr
Peak Load/ft2	5.7 Btu/hr/ft2	7.5 Btu/hr/ft2	14.3 Btu/hr/ft2
AHD*	16.3 MMBtu	25.6 MMBtu	66.4 MMBtu
AHD/ft2	6.9 Kbtu/ft2/yr	10.8 kBtu/ft2/yr	28 kBtu/ft2/yr
* AHD = Annual Heating Demand			

Note: Loads modeled with REMDesign – multiple models with the same house design, 2366 ft2 conditioned space.

Energy Efficient Construction is more than Energy Conserving

- Eliminating thermal bridges increases durability.
- Eliminating thermal bridges increases comfort.
- Eliminating thermal bridges increases indoor environmental quality.
- Triple pane glazing reduces window condensation.
- Triple pane glazing increases occupant comfort.
- Air tight construction increases occupant comfort.

Water Efficiency and Conservation

- Domestic water has upstream and downstream costs
- More cities are experiencing drought and water shortages
- People with wells and SSTS have different issues from people on municipal water and sewer
- Once the building space conditioning loads are reduced, domestic hot water can be the largest energy load
- Two issues: energy consumption and water consumption

Water Efficiency and Conservation

- Create utility cores and/or chases
- Keep plumbing areas near one another
- Minimize length and diameter of distribution piping
- Insulate all hot water distribution pipes
- Consider drain water heat recovery device
- Low flow fixtures, always
- Consider rainwater capture
- Address site water use along with building use

Material Responsibility

Where do we start? “First Do No Harm”

Harm to whom?

- Building Occupants
- Building Constructors
- Current Occupants of The Planet
- Future Occupants of The Planet

So, it gets complicated.

"The Red List"

The Red List contains the worst in class materials prevalent in the building industry.

The commonly-used chemicals on the Red List are:

- Polluting the environment
- Bio-accumulating up the food chain until they reach toxic concentrations
- Harming construction and factory workers

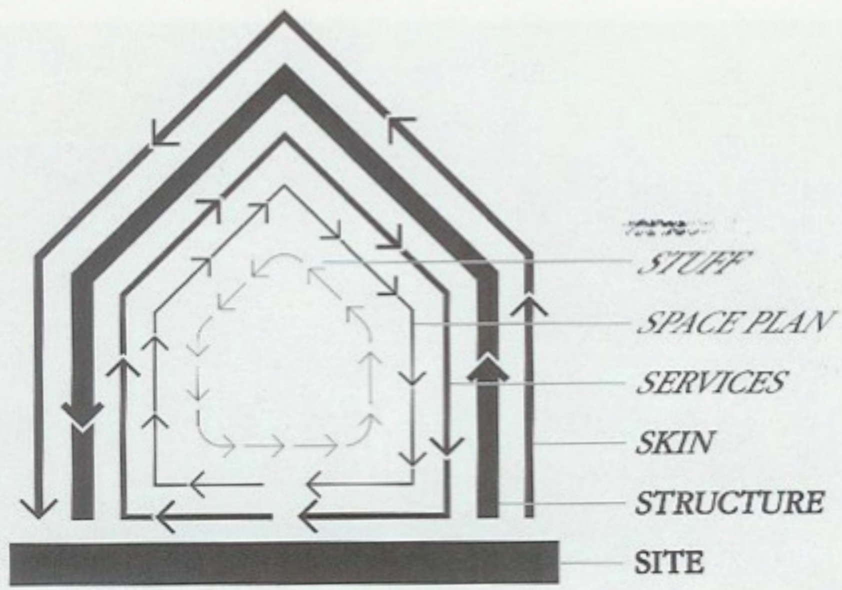
Source: living-future.org/decare/about/red-list

Be (Material) Responsible

1. Reduce
2. Reuse
3. Recycle
4. Buy Local
5. Minimize construction waste
6. Build with knowledge.

Adaptability

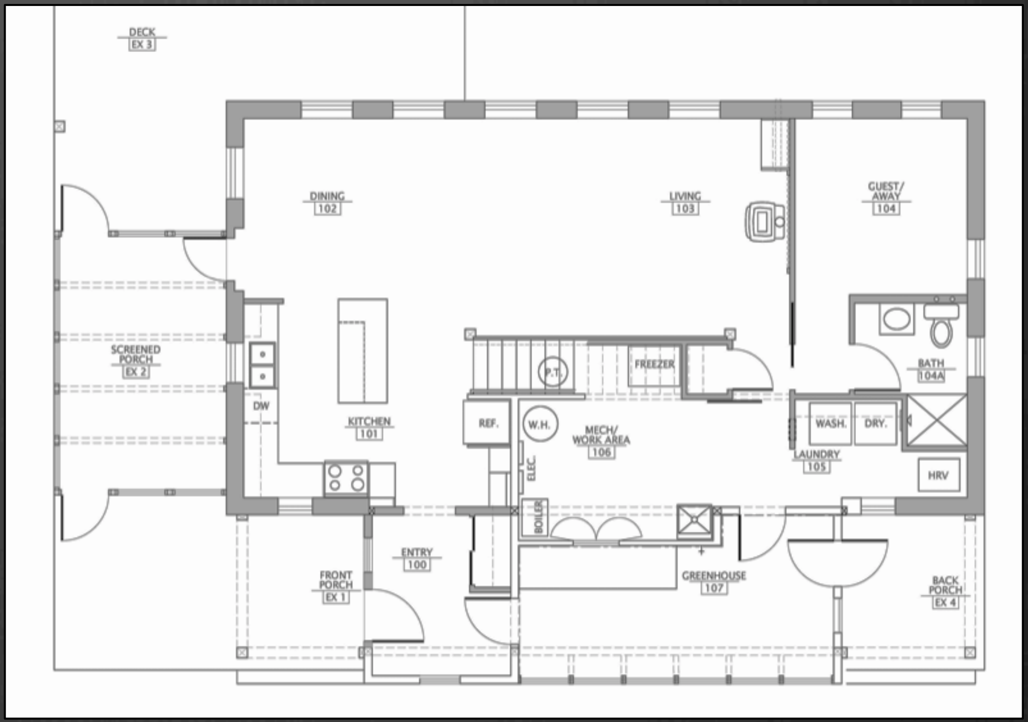
Hierarchy of Layers from “How Buildings Learn” by Steward Brand.
Ironically, Integrated Design can inform what should be segregated.



SHEARING LAYERS OF CHANGE. Because of the different rates of change of its components, a building is always tearing itself apart.

Which assembly is more amenable to future modifications to services?

Resiliency



Durable, robust enclosure
Net zero energy with 6.6 kW roof mounted PV array (affordable operation)
Greenhouse
Active and Passive Ventilation Systems
Wood stove and Passive Solar design

RESILIENCY

E's House
no heat/unoccupied
February 28-29, 2016

Surface Temp	5:30 pm/18 degrees F	6:30 am/3 degrees F
Living Room Floor	56.7	55.5
Living Room Ceiling	59.6	54.3
SW corner, low	54.5	53.1
NE corner, entry door	49.7	51.5
Interior, south glass	59.1	47.9

Design Affects Performance

Just a few of the many things to consider:
Heating and cooling loads
Domestic water use – hot and cold
Appropriate materials
Climate specific building form
Complexity of building form

Good Design

Good Design

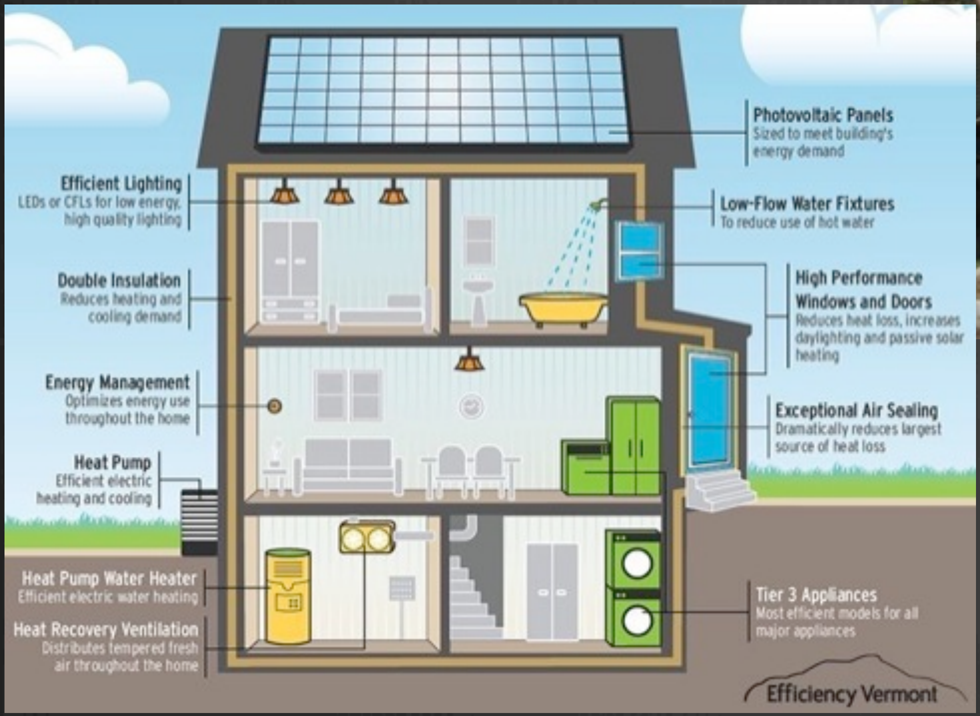
Is high performance affordable?

- Initial first costs will increase, usually by 5 – 15%
- Operating costs will decrease, usually by 30 – 50%
- Long-term affordability of operation matters.
- COST-EFFECTIVE CHOICES MAKE THE DIFFERENCE

What does a high performance house look like?

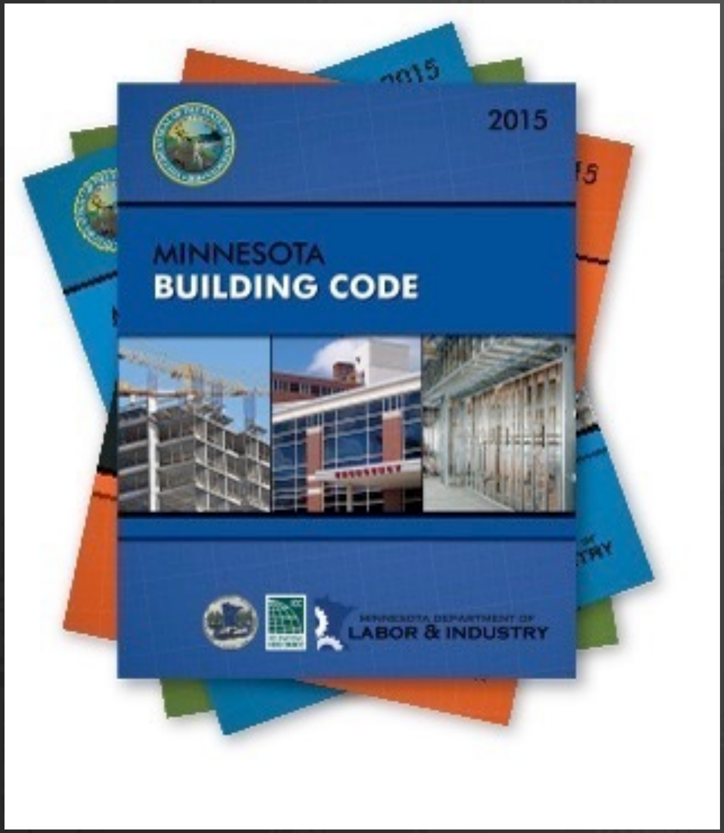
PRACTICE

THEORY



Efficiencyvermont.com

Does Code Get you High Performance?



Segregated Approach

- Not orientation specific
- Not design specific
- Not occupant specific
- Prescriptive vs Performance

Why Build This Way?

- ✓ Consumer demand for this is rising.
- ✓ Differentiate yourself/your business
- ✓ Offer more comfort and more value to your clients
- ✓ Tailor your homes to a particular market segment
- ✓ Fewer callbacks
- ✓ Reduce the impact on the planet

Thank you.

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