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 code/energy hours of credit toward Building Officials and Residential Contractors continuing education requirements."

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Systems Thinking and Integrated Design

Duluth Energy Design Conference
22 February 2023

JUST HOUSING

Where are we going?

1. Overview of Systems in Buildings
2. Why It Matters: Interactions
3. Integrated Design
4. Integrated Design Examples
5. Energy and Integrated Design
6. Greater or Less than the sum of its parts?
7. Takeaways + Practical Advice

Overview of Systems in Buildings

System

noun

a set of things working together as parts of a mechanism or an interconnecting network.

"the state railroad system"

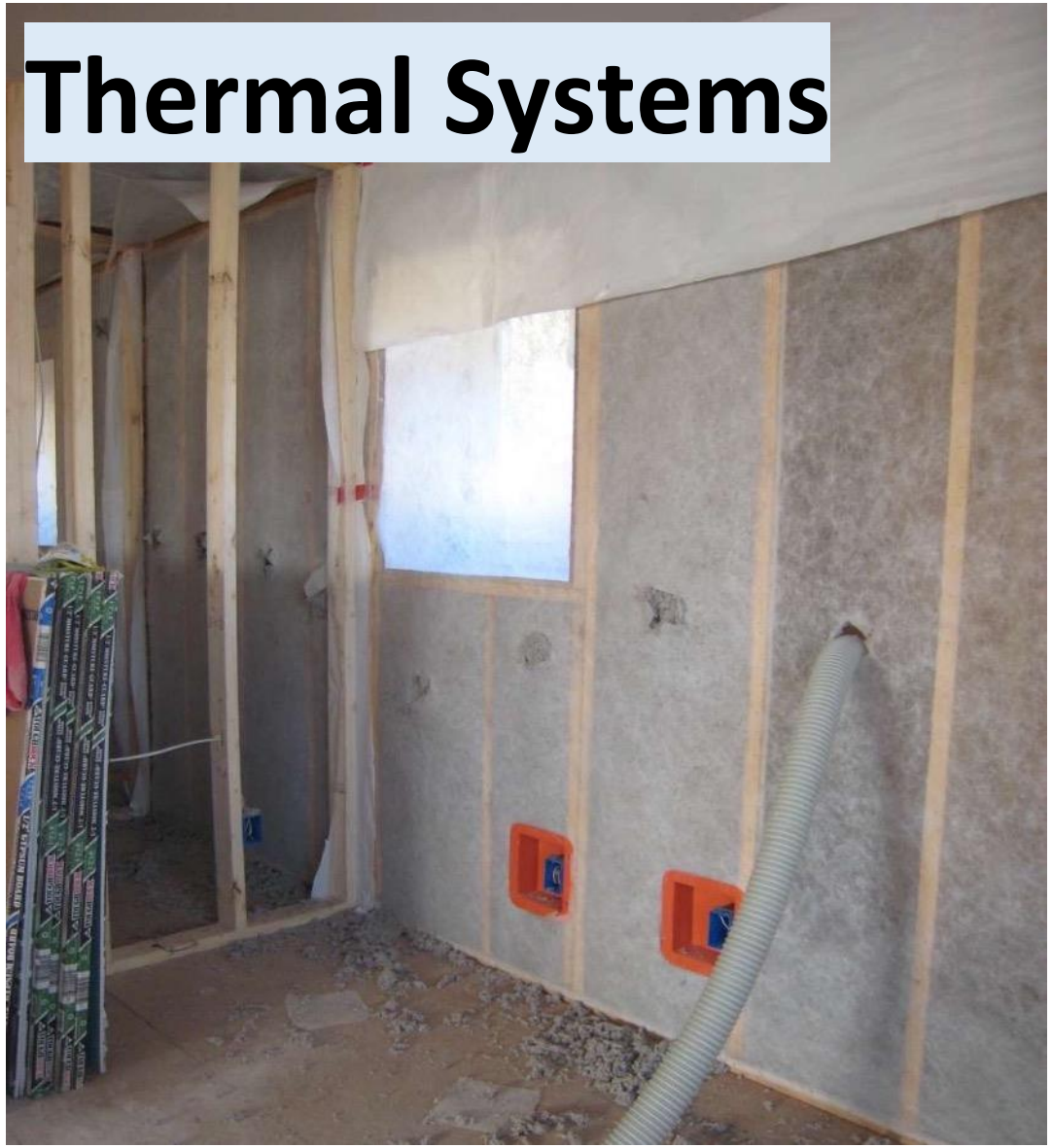
Systems Thinking: Seeing the forest AND the trees

Structural Systems

Structural Systems

Enclosing Systems

Thermal Systems



Mechanical, Electrical, Plumbing Systems

These systems support the comfort and activities of the occupants - but may also serve to maintain the durability of the building by "supporting each other."

AKA "Services"

- Energy/Power
- Heating
- Cooling
- Ventilation
- Water
- Sewer
- Appliances
- Lighting
- Everything else electrical

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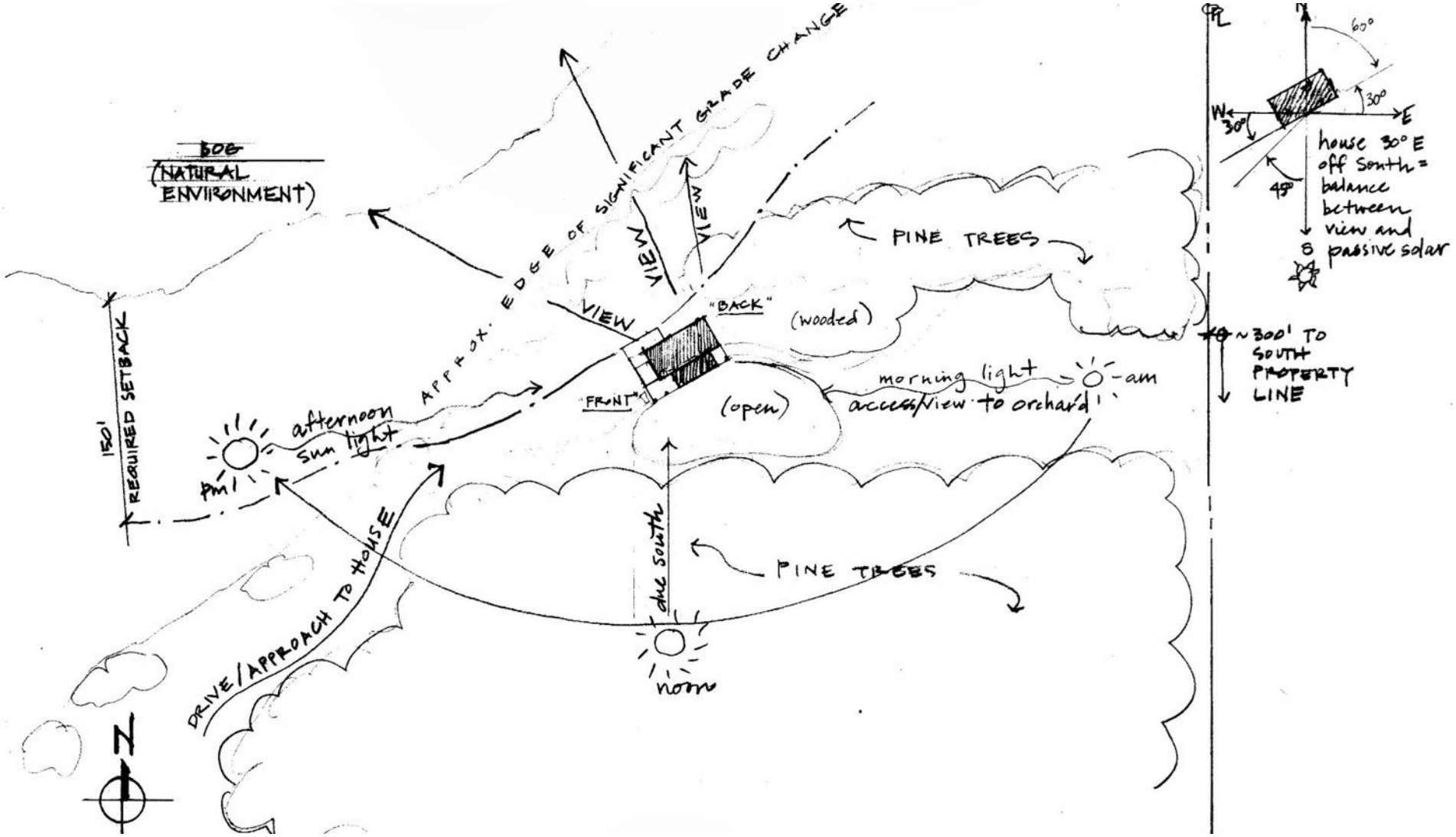


The site and surroundings

Space Plan is a System

As with all systems …

Poor space planning, the system functions poorly.

Good space planning, the system functions well.

Occupancy – an unpredictable system

Occupants vary in number, activity, duration, and impact. They are often one of the most unpredictable systems of the house.

People do things.

People and the things they do interact with the other systems of the building, intentionally or not.

Why It Matters: Interactions

Building a house: It's not just carpentry

- Each system is doing something, or **some things**.
- When one system encounters another system, will both systems still function as intended?
- Will the systems interactions support occupant comfort and health?
- Do the systems, taken together, still meet the required codes?

Can all of the systems of the house work together as the parts of a whole?

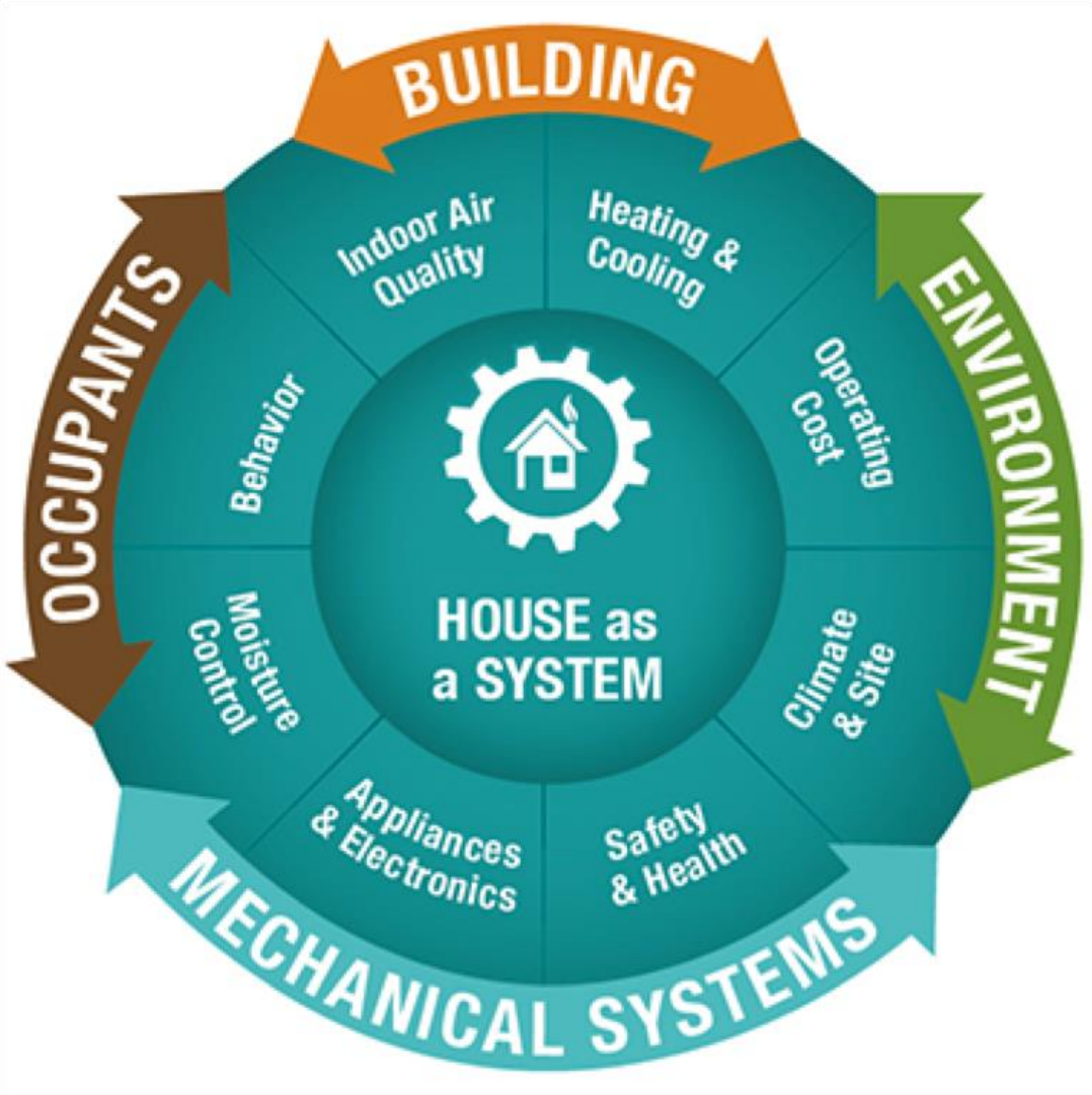


Image from the Canada Home Performance Stakeholder Council

https://homeperformance.ca/

The different systems INTERACT with and AFFECT each other …

so much so that a concept was formed called

"the house as a system."

Integrated Design

Intentionally planning the building so that the interactions of the systems

- support each other,
- don’t interfere with each other
- and even enhance each other

PLAN AHEAD

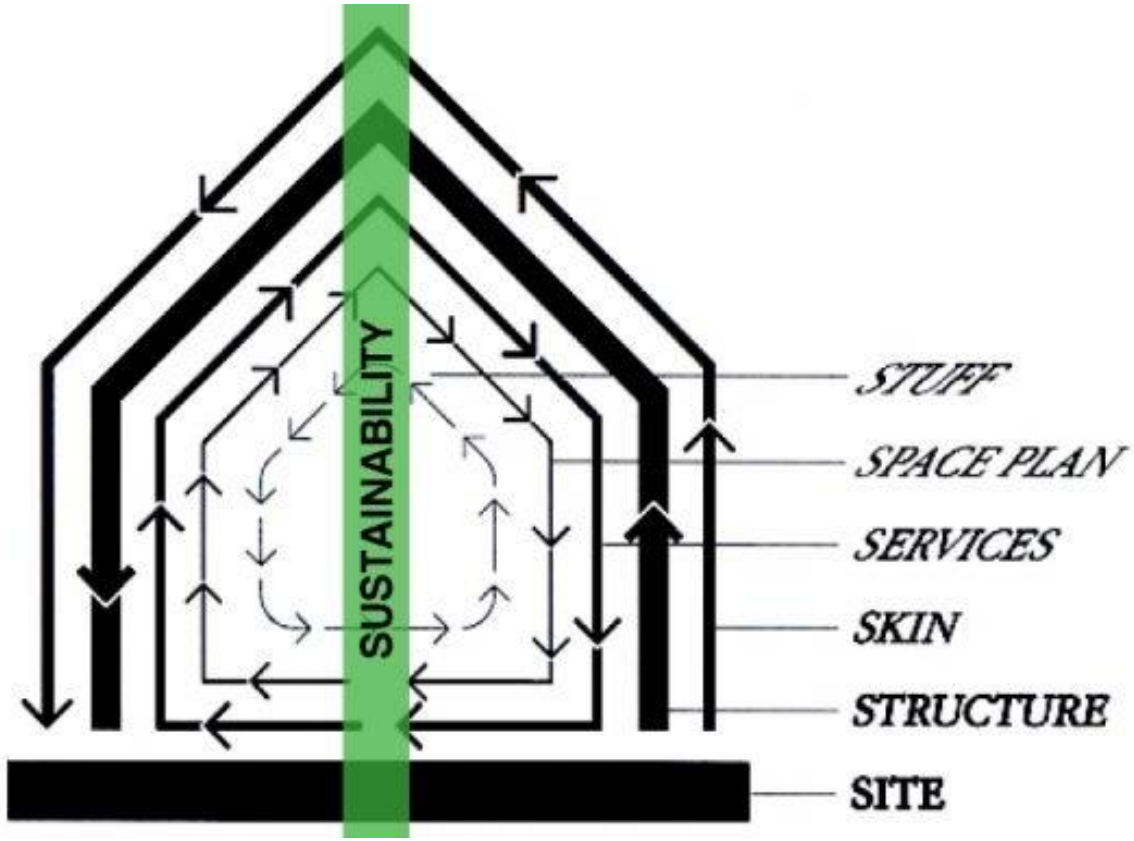
Intentionally plan and deliver DESIGN AND CONSTRUCTION ACTIVITIES so that the interactions of the systems support each other, don’t interfere with each other, and even enhance each other.

Integrated Design: It's INTENTIONAL

1. Uses systems thinking
2. Starts before design
3. Is an ongoing process
4. Considers INTERACTIONS
5. Anticipates operation of the building as a system
6. Considers the future

Not all systems have the same lifespan

Image from "How Buildings Learn" by Stewart Brand



What lasts the longest?

Where should you invest more thought, money and time?

When you need to replace it, can you get to it?

Integrated Design Examples

Interference vs Enhancement

More than a room with a view. Orientation, window and shading choices can help manage energy and comfort, or cause discomfort.

Theory vs Practice: Enclosure, Thermal, Structure

Cavity insulation is often integrated into structure.

How and how often will it be disrupted?

Double stud wall + spray foam insulation.

Thermal system “stuck” to the structure

Electrical and plumbing in there too.

Serviceable? Adaptable?

Layering enclosing and thermal systems

Nailbase panels:
non-structural sheathing layer adhered to rigid insulation layer

This assembly manages heat and air.

Integrating continuous insulation:

- cladding attachment
- window and door location
- window and door attachment

Layers and integration for durability and access

Durable Layers, Fewer Steps

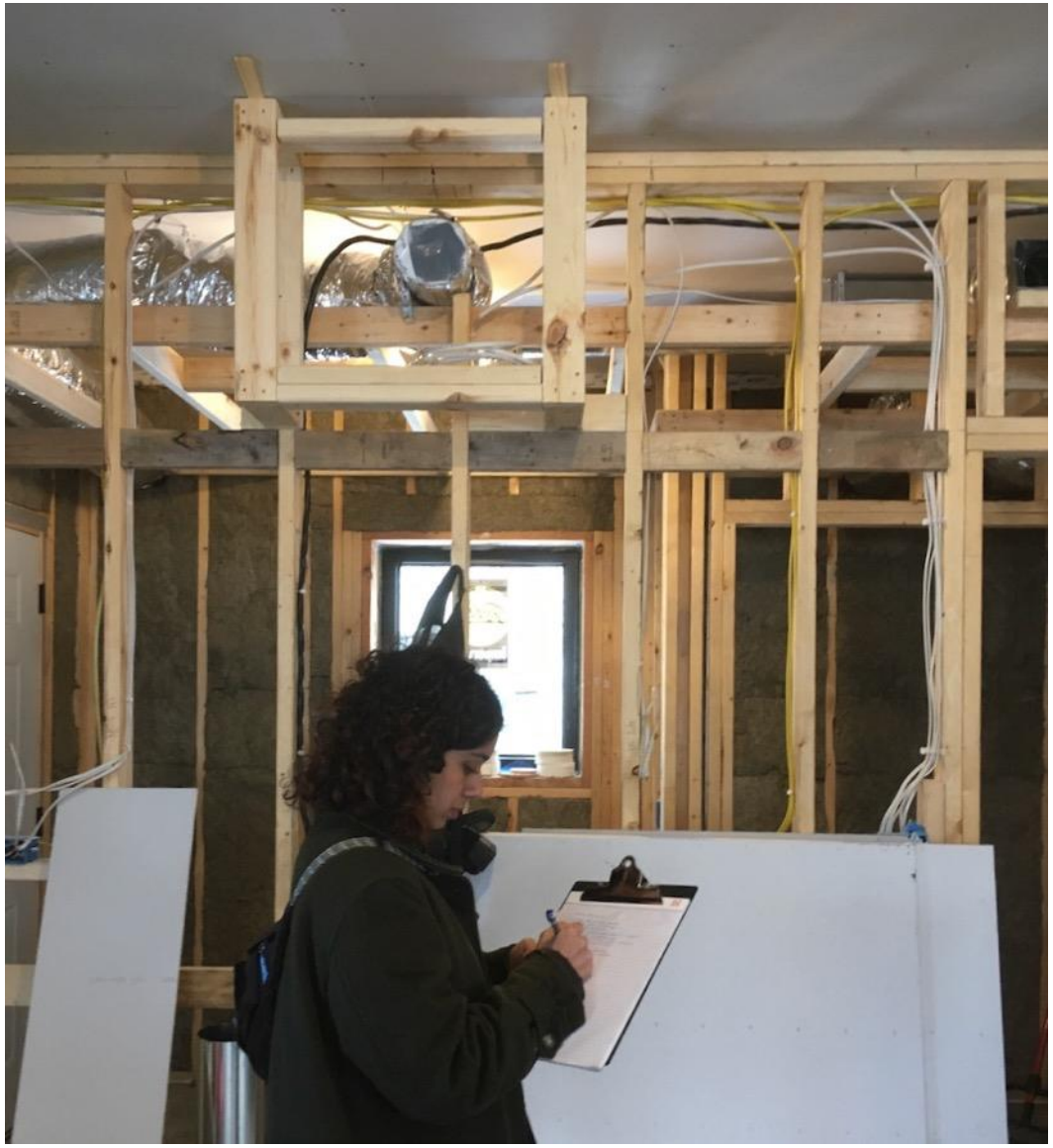
for managing water, air, heat, and time.

Theory vs Practice: Integrated Design for MEP

Floor Trusses

Helps integration, but …

- How many systems?
- Who should go first?
- Accessible?
- Serviceable?
- Adaptable?



Systems Thinking

This Took Planning:

Soffit to contain and connect range exhaust duct at exhaust hood.

Dropped ceiling to route duct to outside wall.

Duct route to keep duct hood 3’ from operable window.

Soffit framing and mechanical distribution all below the air barrier at the ceiling.

Theory in Practice: Integrated MEP

Energy and Integrated Design

Energy Balance of enclosure + systems

Energy conserving enclosure first.

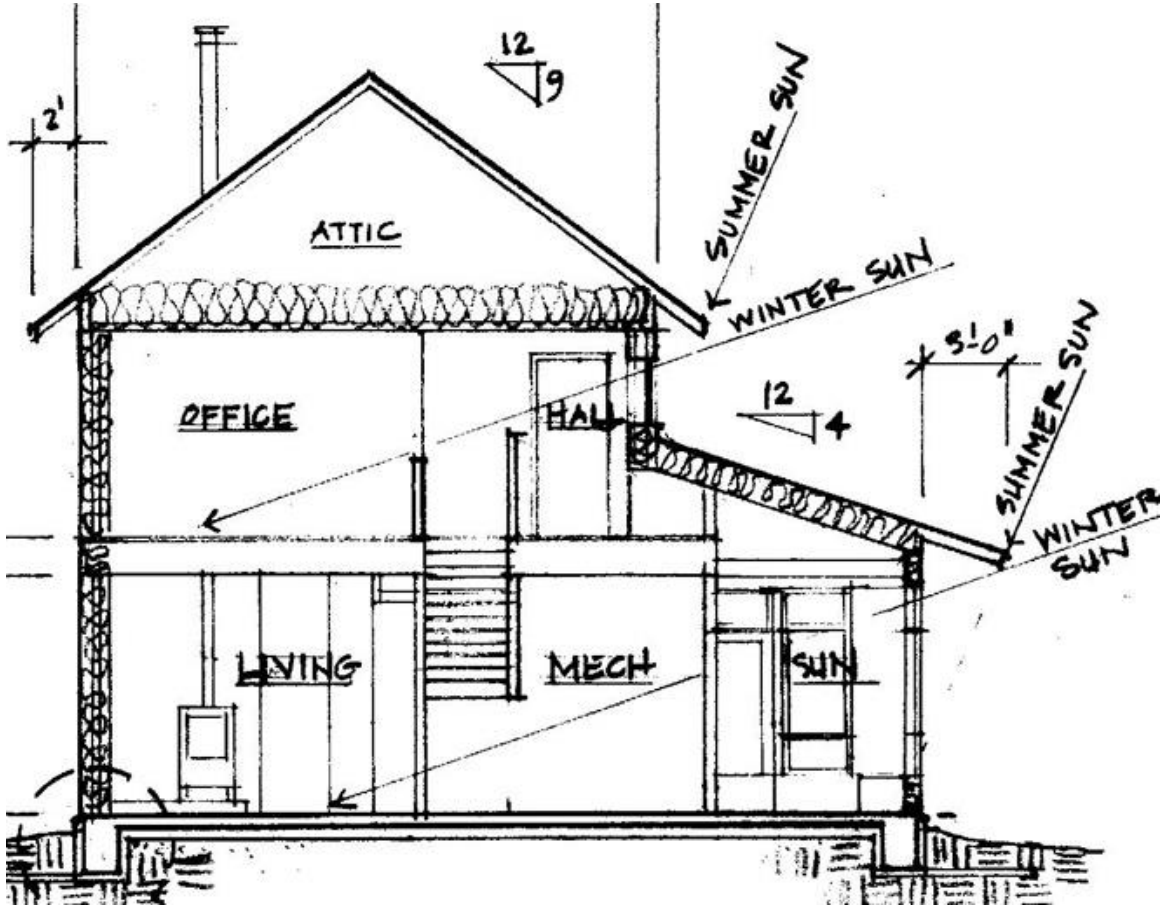
Balance the enclosure:

- higher R-values
- minimize thermal bridges
- robust air barrier
- Appropriate windows

Add super-efficient mechanical systems.

Know how the house will perform without the systems.

Passive Solar: Integrating Resilience, Comfort and Free Clean Energy



Sometimes less is more and more is less

Well planned and executed integrated design can reduce energy use by 50-75%

More layers (insulation and glazing)
Less thermal bridging
More air sealing (<1.0 ACH50)

LESS HEAT LOSS
LESS PURCHASED ENERGY

Less north, east and west glass
More south glass

MORE COMFORT
LESS PURCHASED ENERGY

More water management

LESS MAINTENANCE

Low energy: 5 kW heats a 1500 ft2 house

5 kW = 17k Btu/hr, the peak demand for the house.

Heat (and cooling) will be delivered with a cold climate ASHP.

INTEGRATED DESIGN resulted in the low heating demand.

Greater or Less than the sum of its parts?

Greater than the sum of its parts

Solar-optimized house with super-insulated enclosure, healthy indoor air quality, and passive and active renewable energy systems.

+/- Site/Orientation

\+ Building form

\+ Thermal Control

\+ Energy Use

\+ MEP Systems

\+ Space Planning

= Durability

= Resiliency

= Comfort

= Affordability

Less than the sum of its parts

Solar-attempted house with standard code enclosure, large masonry chimney extending outside, too much glazing, overly reliant on mech. services for comfort.

+/-	Site/Orientation
+/-	Building form
-/+	Enclosure
-	Energy Use
-/+	MEP Systems
-	Space Planning
=	Vulnerability
=	Discomfort
=	Expense

Greater than the sum of its parts.

➔ Independent structural wall
➔ Sealed Structural sheathing for a durable air barrier.
➔ Nailbase panels add continuous insulation
➔ Porch structure separated
➔ Services in service cavities
➔ Layers of access

Embedded isn't the same as integrated.

➔ SIP walls = structure and insulation integrated; cannot be separated

➔ Continuous insulation has chases running through wiring

➔ Adaptable?

➔ Repairable?

Takeaways:
practical advice for implementation

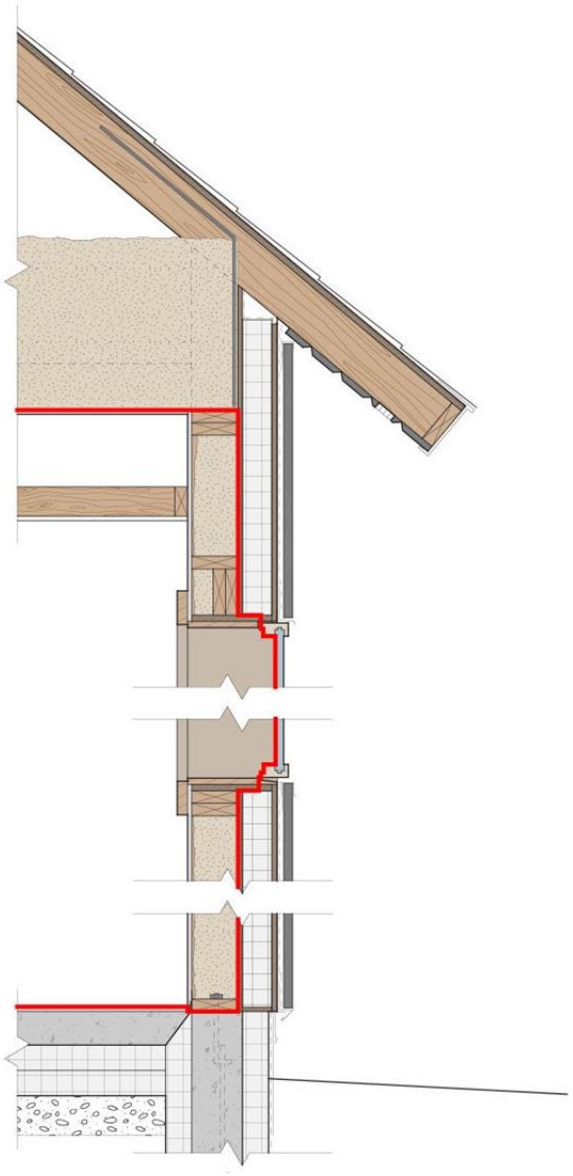
Comfort, Durability, & Resiliency

Use Integrated Design to think long-term about:

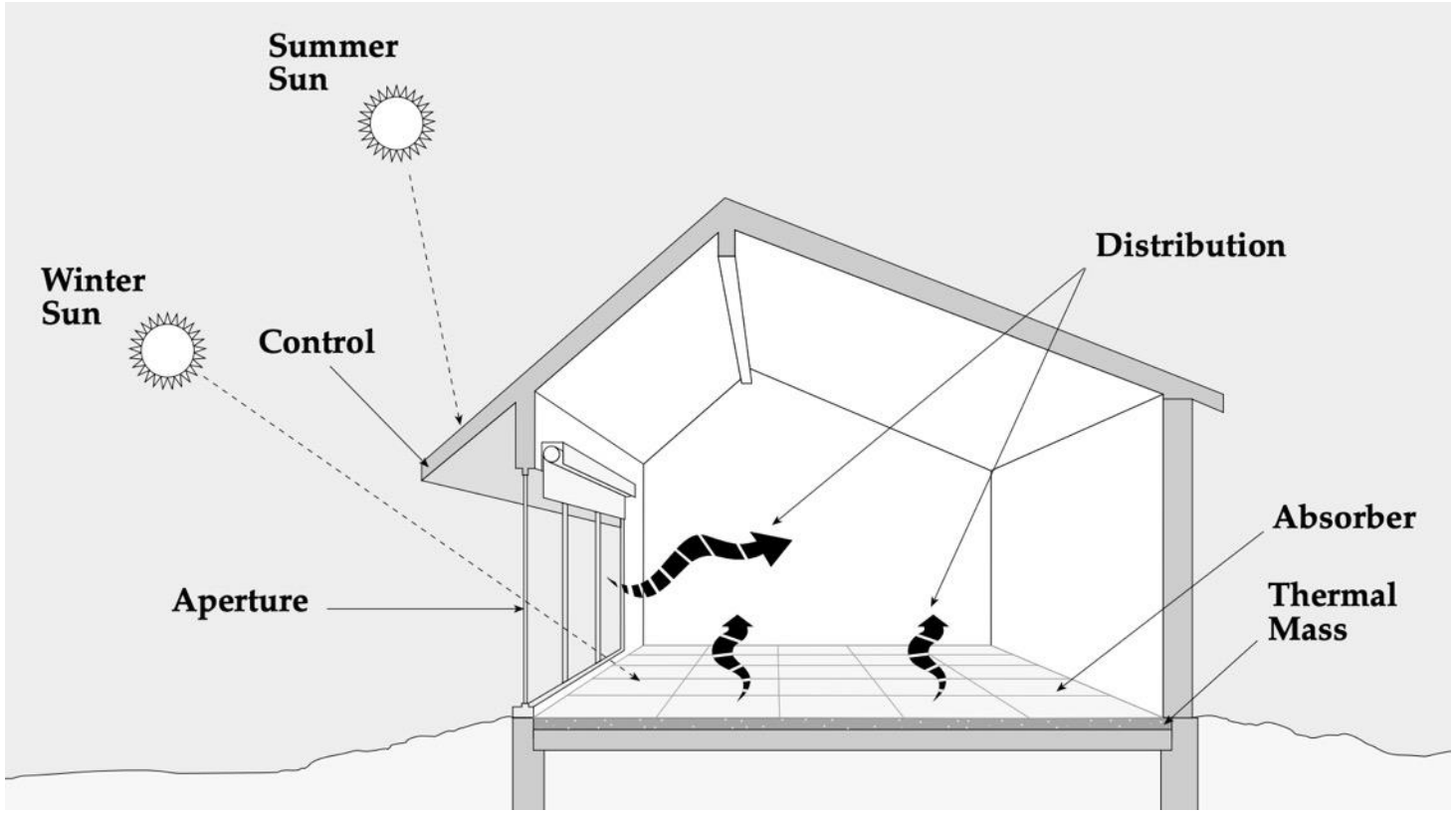
- Occupant safety, comfort and health
- Water management and material durability (moisture/mold/rot)
- Energy consumption

How:

1. Define all of the elements of the assembly needed to create a continuous air barrier.
2. Give continuous insulation a chance – well done, it is worth it.
3. Plan the materials and connection methods before you build.
4. Test the air tightness of the building … *with time to seal weaknesses in the air barrier.*
5. Provide balanced mechanical ventilation for occupants.
6. Exhaust polluted air from cooking separately.



Passive Solar: Integrated Design to Guide Design



Principles to Follow:

1. Triple pane glazing
2. High SHGC (> .40)
3. <10% window to floor area
4. Open floor plan
5. Control with roof overhang

With proper design, a house in Duluth can utilize 90% of solar gains between Oct and April

Duluth Summer Solstice 67 degrees altitude; Winter Solstice 20 degrees altitude *geotimedate.org/sun/usa/mn/duluth*

Better Integration of MEP systems

Lowered Ceilings, Chases and Soffits

Planning Ahead in Design and Building:

- Dedicated distribution
- Straightforward distribution
- Future access to systems
- Air and vapor control layers intact

Plan Ahead In Practice: Integrated MEP

Framing

Air Barrier Continuity

Electrical Rough-In

Mech Penetrations

Air Barrier Continuity

Complete Insulation

Soffit Ledgers

Plumbing Runs

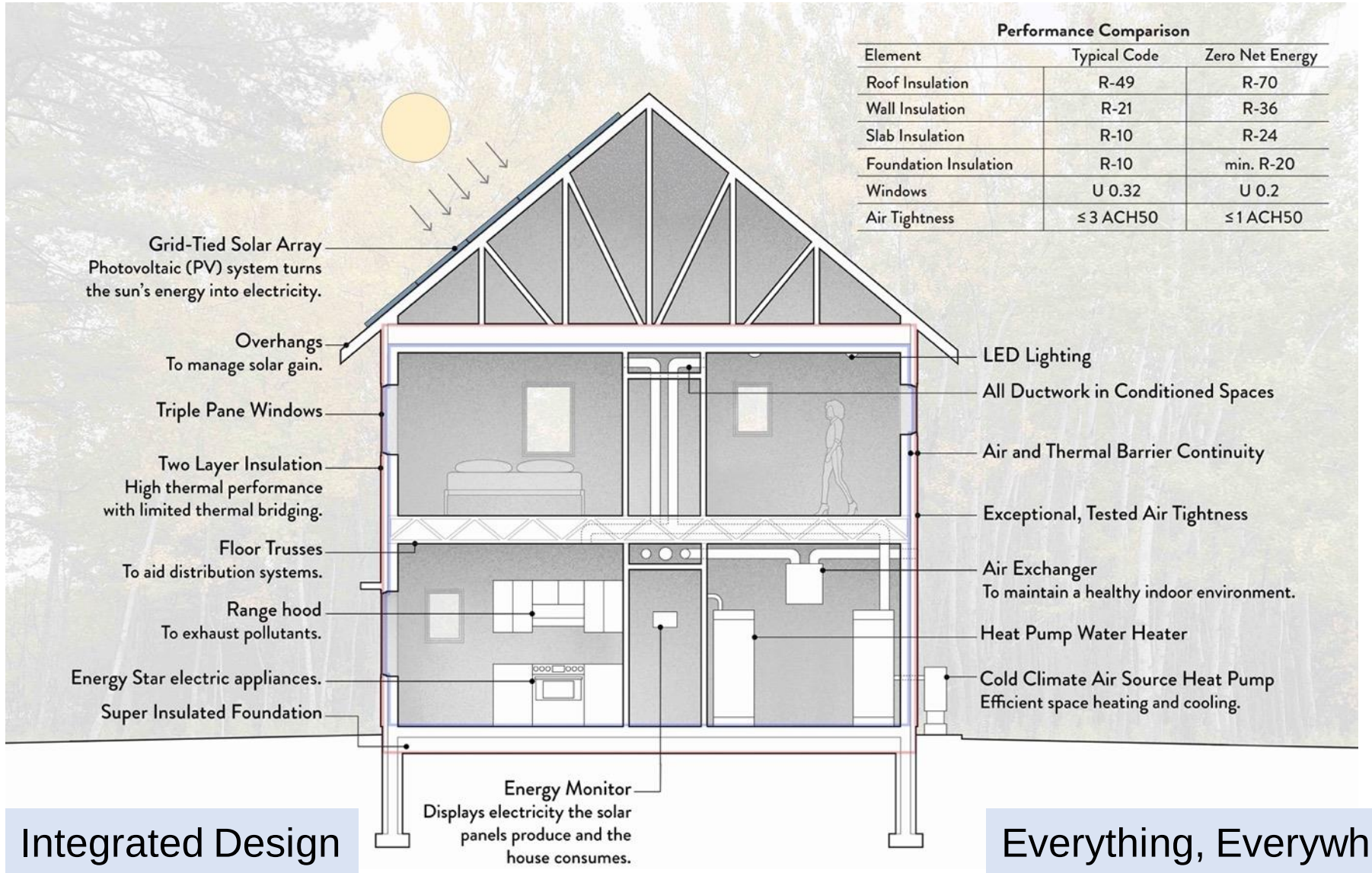
Duct Runs

Soffit Framing

Gypsum Wallboard

The need for renovation brings opportunity.

Integrated design for the next generation.



Integrated Design

Everything, Everywhere, All At Once

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