RETHINKING THE WAY WE LIVE:
A CASE FOR PASSIVE HOUSE RETROFITTING

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WHAT IS A PASSIVE HOUSE?

- Rigorous, voluntary standard for energy efficiency in a building to reduce its ecological footprint
- Ultra low-energy buildings that require little energy for space heating and cooling
  - Average energy savings around 80% (some even up to 95%)

**Characteristics:**
- Fresh, clean indoor air
- Comfortable
- Less expensive to operate
- Low energy consumption
- Super insulation
- Airtightness
- Consistent temperatures
- Slow temperature changes
PASSIVE HOUSE STATISTICS

- Approximately **10,503** certified passive houses in the world
  - #1 Germany: 7098
  - #12 USA: 38
- On average, passive houses are **more expensive upfront** than conventional buildings
  - 5% to 8% in Germany
  - 8% to 10% in UK
  - 5% to 10% in USA
- Germany: now possible to construct buildings for the **same cost** as those built to standard German codes
- EnerPHit standard is fairly new (2012) and has a **different set of criteria** than a new passive house
  - Very few retrofits have met criteria
ENERPHIT CRITERIA

- Specific Heat Demand $\leq 7.9 \text{ kBTU/ft.}^2$
- Airtightness $\leq 1.0 \text{ ACH50}$
- Specific Primary Energy Demand $\leq 41.2 \text{ kBTU/ft.}^2$
RESEARCH QUESTIONS

• Is it possible to retrofit ordinary conventional homes to the PassivHaus Institut’s EnerPHit Standard?
  • And is it worth the cost?
• What are the socio-economic implications of retrofitting or designing a passive house?
PROJECT INFORMATION

- **Location:** Ames, IA
- **Climate Zone:** 6
- **Housing Type:** Single-family house
- **Year Built:** 1948
- **Total:** 1,295 sq. ft. (above ground)
- **2** stories + basement
- **4 bed + 1 bath**
- **Approximate Value:** $175,168
- Currently used as a rental property
WALL ASSEMBLY:
R-value = 9.7

ROOF ASSEMBLY:
R-value = 11.6

FLOOR ASSEMBLY:
R-value = 13.0

GLAZING:
R-value = 2.04

LOW PERFORMANCE WINDOWS
- Double-pane glazing with vinyl framing and no insulation
- Poor sealing around crevices

NO INSULATION AT OR BELOW GRADE
- Thermal bridging occurs

INSUFFICIENT INSULATION
- Balsam wool batt insulation with standard 2 x 4 studs
- Lots of air leakage and infiltration

LOW PERFORMANCE EXTERIOR DOORS
- 1 3/4" thick doors with little to no insulation
- Poor sealing around crevices
BUILDING EVALUATION

- Structure
- Insulation
- Airtightness
- Moisture management
- Ventilation/Air quality
- Comfort
- Daylight
MEASUREMENT TOOLS

- **HOBO data logger**
  - Measured indoor temperature and relative humidity for the two main floors of the house

- **FLIR infrared camera**
  - Used to find air leakage on a visual level
PASSIVE HOUSE PLANNING PACKAGE (PHPP)

- Large Excel spreadsheet with individual worksheets that are interconnected with one another
- Accurate calculations
- Quick, easy way to test design modifications and to verify passive house requirements
- Used to get certification
CURRENT PERFORMANCE DATA

- Annual Heat Demand: 17.8 kBTU/ft.²
- Annual Cooling Demand: 3.4 kBTU/ft.²
- Air Leakage: ~6.0 ACH50
  - Older homes – 5 to 10 ACH50; Newer homes – 3 to 5 ACH50
- Annual Utility Cost: $2134.57 or $177.88/month
  - Gas heating cost from December to March: $554.86
  - Annual electricity and water cost: ~$1579.71
Above: East Elevation
Right: Poorly insulated concrete foundation
Windows and doors account for a large percentage of air leakage due to improper sealing and low R-values.
Balsam wool batt insulation (likely the original insulation) is seeing a lot of wear and tear these days and is most likely contributing to the roof’s poor insulation value.
ENERPHIT COMPARISON

- Specific Heat Demand: **18.3 kBTU/ft.²** (≤ 7.4 kBTU/ft.²)
- Airtightness: ~**6.0 ACH50** (≤ 1.0 ACH50)
- Specific Primary Energy Demand: **101.3 kBTU/ft.²** (≤ 41.2 kBTU/ft.²)
WHAT CAN BE DONE?

- Super insulation (10” to even 18” thick walls)
- Reduce thermal bridging
- Higher R-value materials
- Better windows and doors
- Tighten up the envelope
- Improve ventilation
- Energy efficient appliances and lighting
- Use renewable energy resources to further reduce operational costs
WALL ASSEMBLY:
R-value = 57.4

ROOF ASSEMBLY:
R-value = 54.6

FLOOR ASSEMBLY:
R-value = 49.4

GLAZING:
R-value = 8.0

HIGH PERFORMANCE WINDOWS
- Triple-pane glazing with insulated frame
- Higher R-values
- Sealed for airtightness

HEAT RECOVERY VENTILATOR
- Keeps heat in while moving stale air out
- Brings cold fresh air in and mixes with warm air
- Replaces the need for a furnace

INSULATED FLOOR SLAB
- Insulates concrete block walls as well
- Reduces thermal bridging

LARSEN TRUSS
- Simple wooden truss
- Expands the wall cavity to allow for more insulation
- Built onto existing frame

HIGH PERFORMANCE EXTERIOR DOORS
- Thicker than conventional doors
- Highly insulated with a higher R-value
- Sealed for airtightness
RETROFIT PERFORMANCE DATA

- Annual Heat Demand: 4.21 kBTU/ft.²
- Annual Cooling Demand: 3.6 kBTU/ft.²
- Air Leakage: 0.8 ACH50
  - Older homes – 5 to 10 ACH50; Newer homes – 3 to 5 ACH50
- Annual Utility Cost: Up to 75% cost reduction*
  - $25/month vs. $177.88/month
  - Payback period starts as little as 5 years
  - Added value to your house

* Depends on individual lifestyles (up to the owner to be conscious and reduce their usage as well)
DOES IT PASS THE TEST?

- Specific Heat Demand: 5.3 kBTU/ft.² (≤ 7.9 kBTU/ft.²)
- Airtightness: 0.8 ACH50 (≤ 1.0 ACH50)
- Specific Primary Energy Demand: 41.1 kBTU/ft.² (41.2 kBTU/ft.²)
SOLUTIONS FOR THE FUTURE…

- Conventional homes are need of a major retrofit
  - Homeowners should invest in their homes

- New homes need to built to a higher standard
  - Need to modify building code to require airtightness

- Short-term vs. long-term mentality
  - Life-cycle cost analysis

- Public education about passive house standard
  - Creating awareness and understanding

- Ultimately, it’s about priorities…
  - Value of embodied energy
EXTERNAL SOURCES