The Passive House Experience
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Describe Your Ideal House

Where is the human component?
Learning Objectives

1. To understand people’s experience in the design, construction, and occupation of a Passive House project

2. To recognize gaps in resources when designing to the Passive House Standard

3. To review stumbling blocks and their potential solutions of the Passive House Standard

4. To illustrate the importance of the experience of a Passive House
Meet the Parties Involved
Owners: Bob Donough and Lynne Taccogna

Background:
- Bob is a retired math teacher
- Lynne is a community development specialist
- Both are former restaurateurs
Meet the Parties Involved:
Green Hammer

“Green Hammer is a unified design-build firm”...“An integrated, multi-disciplinary team of architects, designers and construction experts that fuse cutting edge design concepts with state-of-the-art building science to deliver the highest and most inspiring results – effectively, efficiently and on-budget – all while enjoying the process.”(Green Hammer)

Meet the Parties Involved:
Green Hammer

Architect:
Dylan Lamar, Green Hammer

Contractor:
Alex Boetzel, Green Hammer
The Taccogna Residence

PV Panels

Garden
Bedroom And Offices
The Utility Room

![Utility Room Diagram]
Bob And Lynne’s Former Home

Photos by Bob Donough
WHY PASSIVE HOUSE?

“We had a choice, we could take our assets, such as they were, and we could put them in some sort of investment portfolio....

...Or we could evolve a lifestyle that says we are going to reduce our costs as much as possible.”

- Bob Donough
Developing Common Goals

Bob Donough stated that we wanted to invest our savings and other assets to create a home that:

1) Minimized our day-to-day living expenses

2) Conserved energy use

3) Was constructed using sustainable building practices

4) Allowed them to “age in place.”
Communication Between Parties

DB communication vs Conventional

“...the team has to be integrated to a much deeper level than even integrated project delivery. There has to be more than that. You literally have to sit at the same table, see eye-to-eye, and try and understand what is being built, why, and how. The designer has to understand what is being put in place and how it is getting sealed, while the field crew and the contractor need to understand what the intention is behind every line to execute them correctly.” - Alex Boetzel
Methodology & Measurement

ENERGY USE
- Constant monitoring of energy usage installed in the utility room of house
  equipment: eGauge monitoring system

THERMAL COMFORT
- Quarterly measurements taken in each room for a duration of 10 days
  equipment: HOBO dataloggers

DAYLIGHTING
- Quarterly measurements taken in main living room at 1 ft intervals
  equipment: Konica Minolta Illuminance Meter T-1H

INDOOR AIR QUALITY
- Quarterly measurements taken in each room
  equipment: Met One 804 particle counter
Energy Use: Findings

*PHIUS Standard:
Primary Energy < 38.1 kBtu/ft² /yr
Annual Heating < 4.75 kBtu/ft² /yr
Energy Use: Quarterly Breakdown
Winter Energy Use/Production
December 20th - 30th 2013
Summer Energy Use/Production
June 20th - 30th 2013

Power (kW)

[2pm]
Clothes Dryer = 4.14 kW

TOTAL
JUNE - SEPTEMBER
OCTOBER - DECEMBER

Consumption
DOLLARS

2,510 kWh $376.50
1,340 kWh $201.00
1,830 kWh $274.50
685 kWh $102.75
1,170 kWh $175.50
2,515 kWh $377.25

NET = $0.75

$400 $350 $300 $250 $200 $150 $100 $50 $0
Annual Energy Production vs Consumption

TIME (Months)
June 2013 - June 2014

Energy (kWh)
0 100 200 300 400 500 600 700 800
Production
Consumption

Legend:
- Blue: Production
- Orange: Consumption

MONTHLY ENERGY PRODUCTION vs CONSUMPTION
Energy Cost

$1,455 vs. $945

Average Housing Stock Yearly Energy Bill
The Taccogna Residence’s Yearly Energy Bill

TIME (Months)
June 2013 - June 2014

ENERGY (kWh)

Energy Cost (Dollars)

$83
$76
$71
$68
$73
$70
$72
$67
$60
$66
$69
$74
$96

Average Housing Stock Yearly Energy Bill

The Taccogna Residence’s Yearly Energy Bill
Energy Cost

$1,455 vs. $180

Our 1950’s Era Home’s Yearly Energy Bill

The Taccogna Residence’s Yearly Energy Bill with PV Generation

<table>
<thead>
<tr>
<th>TIME (Months)</th>
<th>ENERGY (kWh)</th>
<th>Energy Cost (Dollars)</th>
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<tr>
<td>June</td>
<td>$83</td>
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<tr>
<td>December</td>
<td>$96</td>
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June 2013 - June 2014
Impact on the Owner
Impact on the Owner
Picking Products

“The electric cookware, the range and the oven were the worst. Energy star doesn't rate those. We did not know which ones to pick. We ended up picking based on price and features.” - Bob

Photos by Michael Shaw
Analysis of Energy Use

Successes
- Conserves energy/minimizes everyday expenses
- Positively impacts the way the owner operates the house

Stumbling Blocks
- Difficulty specifying products
Thermal Comfort

Background

- It’s all in the details....
- walls = R-52.7
- roof = R-95.5
- floor = R-43
- HRV = Zehnder Comfoair 200

Drawings by Green Hammer
INTERNAL TEMPERATURES

24 hour period: January 27th, 2014

Summary
The Players
Getting it Going
Performance + Issues
Looking Back

Occupant acceptable comfort zone

TEMPERATURE (ºF)

- Indoor
- Bedroom
- Kitchen
- Office
- Living Room

Passive house recommended comfort zone

Occupant acceptable comfort zone
INTERNAL TEMPERATURES

24 hour period: April 27th, 2014

- Occupant acceptable comfort zone
- Passive house recommended comfort zone

TEMPERATURE (°F)

- Outdoor
- Bedroom
- Kitchen
- Office
- Living Room

Graph showing internal temperatures for different rooms and the recommended comfort zones.
INTERNAL TEMPERATURES
24 hour period: June 20th, 2013

- **Occupant acceptable comfort zone**
- **Passive house recommended comfort zone**

Temperature (°F)

- Outdoor
- Bedroom
- Kitchen
- Office
- Living Room

Temperature chart showing internal temperatures from 12 am to 11 pm over a 24-hour period on June 20th, 2013.
INTERNAL TEMPERATURES

24 hour period: October 21st, 2013

TEMPERATURE (°F)

- Outdoor
- Bedroom
- Kitchen
- Office
- Living Room

Passive house recommended comfort zone

Occupant acceptable comfort zone
Issues and Solutions
Air Barrier and the slab

-Delays in window delivery
-In order to keep on schedule the slab was poured with only a visual inspection
-Used the slab as the air barrier instead
Issues and Solutions
Siga Tape Problems In The Roof Assembly

-One of the first times they used that product
-Built in properties of the tape were not taken into account (ductility)
-Rep to the rescue!

Photo by Green Hammer
Issues and Solutions
New Product - Expanding Foam Tape

- First Generation
- 3-in-1 product
- Did not perform as expected

Photo by Green Hammer
Issues and Solutions
Limited Product Availability

-When asked about the gaps in resources Alex said product availability was the first thing that came to mind.

- A need for local systems and products are going to be in demand
Analysis of Thermal Comfort

- A need exists for more products manufactured in the United States.
- Don’t be afraid to ask for help!
- Work closely with the project team to find solutions to problems
- Be flexible
Light Quality
Winter
(January 26, 2014)
Summer
(June 20, 2013)
Fall
(October 20, 2013)
Findings

Bob explaining that he does NOT need light on his counter tops to cut his vegetables
Analysis of Light Quality

Bob explaining that he does NOT need light on his counter tops to cut his vegetables

Photo by Green Hammer
Indoor Air Quality
**CO₂**

Basis indicator of proper ventilation

- 700 ppm above outdoor is the baseline measurement for proper ventilation
- 1,000 ppm odors and stale air may begin to be detected
- 5,000 - 40,000 ppm starts to affect physiology
- > 40,000 causes immediate harm
WINTER
(January 27, 2014 - February 7, 2014)

ASHRAE Allowance = 1,023
Outdoor CO2 Level = 323
SPRING
(April 26, 2014 - May 7, 2014)

Outdoor CO₂ Level = 323
ASHRAE Allowance = 1,023

04/26 04/27 04/28 04/29 04/30 05/01 05/02 05/03 05/04 05/05 05/06 05/07

CO₂ (ppm)
SUMMER
(June 16, 2013 - June 26, 2013)

Outdoor CO2 Level = 323
ASHRAE Allowance = 1,023
FALL
(October 21, 2013 - October 31, 2013)

Outdoor CO₂ Level = 323
ASHRAE Allowance = 1,023
Particulate: Why does size matter?

- 90 μ: fine grain sand
- 70 μ: human hair
- 10 μ: dust, pollen, and mold
- < 2.5 μ: combustion particles, organic compounds, and metallurgical dust

- 100 μ - 10 μ: Inhalable Dust
- 10 μ - 2.5 μ: Thoracic Dust
- < 2.5 μ: Respirable Dust
WINTER
(January 26, 2014)
SPRING
(April 26, 2014)
FALL
(October 27, 2014)
Comparison
(June 14, 2013 vs. October 20, 2013)

Number of Particles

- Porch (Jun.)
- Porch (Oct.)
- Guest room (Jun.)
- Guest room (Oct.)

Comparison:
- 1.0 μ
- 2.5 μ

Graph data:
- Porch (Jun.): 10,000
- Porch (Oct.): 80,000
- Guest room (Jun.): 20,000
- Guest room (Oct.): 20,000
Deal Breakers

Who knows what this is...?
Deal Breakers
Analysis of Indoor Air Quality

- CO2 and Particulate counts are all at acceptable levels
- Creative solutions to difficult problems were solved by communication and flexibility
Stumbling Blocks Along the Way

Potential
- Poor Communication
- Misaligned Goals
Stumbling Blocks Along the Way

Potential
  - Poor Communication
  - Misaligned Goals

In our case
  - Product Unavailability
  - Product Delays
  - Not enough product and equipment information
  - Specific desires from Bob and Lynne
Stumbling Blocks Along the Way

Potential
- Poor communication
- Misaligned goals

In our case
- Product unavailability
- Product delays
- Not enough product and equipment information
- Specific desires from Bob and Lynne

Overcoming the blocks
- In depth research was done on products from all parties
- Extremely efficient communication
- Experimental design solutions
- Willingness to adapt to the home
Looking Back

Why is this such a successful project?
Looking Back

Why is this such a successful project?

- Within budget
Looking Back

Why is this such a successful project?
- Within budget
- Everyone is happy with the product
Looking Back

Why is this such a successful project?
- Within budget
- Everyone is happy with the product
- Everyone is still talking to each other!
Looking Back

Why is this such a successful project?
- Within budget
- Everyone is happy with the product
- Everyone is still talking to each other!

How was the project successful
Looking Back

Why is this such a successful project?
- Within budget
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How was the project successful
- Collaboration
Looking Back

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How was the project successful
- Collaboration
- Communication
Looking Back

Why is this such a successful project?
- Within budget
- Everyone is happy with the product
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How was the project successful
- Collaboration
- Communication
- Experimentation
Discussion of long term solutions

- Empowering the owner
- Marketing the Passive House Standard
- Centralized knowledge
- Collaboration, collaboration, collaboration
- All comes down to the human experience.
Questions? A two way street

How do we make these solutions a reality?
Acknowledgements

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