ADVENTURES IN DESIGN:
Realizing the First, Affordable, Multi-Family Passive House Project in (Kind Of Cold) Vermont

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Disclaimer: This presentation was developed by a third party and is not funded by WoodWorks or the Softwood Lumber Board.
In 2012 I wanted to do two things: MAKE an affordable, multi-family Passive House AND
for 5 years I was frustrated

AND THEN

Bridget Bardot

The Pope

Jane Fonda

Looks like my parents

A Bocce Court
Simultaneously stunned and terrified by beauty
Stimulated toward the spiritual
Overtaxed by indeterminacy
Threatened with annihilation
Reassured by God.

When they said ‘Let’s explore Affordable Passive House’
I felt the Sublime. WHY?

THE SUBLIME
From Longinus, Burke & Kant to American Transcendentalism
Thomas Cole - Painter
Overtaxed by indeterminacy

VERMONT NON-PROFIT FUNDING MECHANISMS DON’T ITERATE
• Can’t take a year - Once funded, Boom! - 4 - 6 to bidding
• Fees can’t afford roomfuls of people iterating
• Need familiar systems with local service and track record
• Can’t increase budget (well....just a little bit)
• Design (quickly) — Passive House, or not — based on cost
• Pretty much have to hit it first try—minimal iteration

PASSIVE HOUSE
logical, straightforward, iterative
design, model, test, cost
refine systems & details
hone the Solution

What I Heard____TIME
a full year. many team meetings for many hours.....iterating

THE ORCHARDS AT ORENCO -1st Multi-Family Passive House in US
Ankrom, Moisan Architects, Inc.  Michael Bonn - Project Architect  Photo - Casey Braunger

BREWER, MAINE
CWS Architects—Thornton Tomasetti

ITERATIVE PROCESS
Angels Dancing On The Head Of A Pin
PREVIOUS PROJECT
Same Non-Profit Client

Our Lucky Star
Starting from solid baseline

The commitment to comfort for senior population meant we were already making a pretty good building.

WRIGHT HOUSE - SHELBURNE, VT

36 Senior Dwelling Units + Common

- Near Passive House Air Tightness
- R60 Parking Garage Ceiling & Roof
- R21 Stud Cavity + R7.5 Continuous Foam
- Hydronic Heat (Natural Gas)
- ASHP Cooling - Being in base bid was Critical to our Elm success
- Central ERV - Being in base bid was Critical to our Elm success
- U=.28 Windows

Maybe the PH jump was not that big. Stretch rather than re-invent, save time.
**Elm Place**  
**30 Dwelling Units + Common**

**Site**
- Suburban, first in new town center, be more urban
- Narrow, angled from street, east/west primary solar orientation

**Concept**
- Agglomeration of cells - 2 story shifted box over parking
- Common spaces go a little crazy outside the box
- Energy model - Benefits of surface to volume ratio of large structure
- Do our usual, but a bit better: Wood box, exterior insulation.
- Preliminary Costs - Seemed to be OK

- CLIENT commits, CM, MPE and rest of team assembled

**Inspiration: Cathedral**
Agglomeration of simple cells
Go a little crazy for important spaces
Good recipe for Passive House
REALITY CHECK

CM 1st Estimate
1M (20%) Over Budget!

PH not main problem.

Market Conditions
Soils/seismic 120k
Etc.

START ITERATING!!!

BUILDING MEAN & LEAN CRASH DIET

- Reduced footprint by about 4,000 sf - shrunk program & common space
- Simplified Walls - 3” of foam ILO I-joists with dense pack cellulose
- Changed Roof - R70 foam killing us!
- Dreaded vinyl siding on back section………
- Wish Items moved to contingency:
  Gypcrete, emergency generator, photo voltaics, parking garage screen,
  sun shades on south windows, additional shelving/cabinets/counters etc.,
  bocce court, pergola, exercise path, landscaping, fireplaces, grill.
AIR BARRIER

- Slab on Grade or Elevated Garage Slab
- Sheetrock below garage suspended insulation
- Zip sheathing on exterior of wood framed walls
- Zip sheathing on top of wood roof structure

WHAT WE DID
Final Plans & Details
FOUNDATION INSULATION

- Foundation - Still astounded at the amount of foam
  - R20 - 4” for SOG
  - R 40 - 10” encasing walls
- Not about heat loss - keeping temp above dew point to avoid condensation
- Shallow, frost protected instead of full frost wall to save foam
- Fortunately, limited footprint since most is uninsulated parking garage
- Vapor Retarder connected to air barrier
- On new projects we are using EPS foam ILO XPS since better for environment
WALL NOTES

- R21 Cavity + R 18 = +/- R38
- 2x6 Stud with ZIP Air Barrier, HD fiberglass, 3" polyiso foam (2 conditions)
  Condition 1 @ Fiber Cement - 3" foam, WRB, rain screen
  Condition 2 @ Vinyl Siding - 3" single sided SIP, WRB
- Panelizer shop drawings did not show 1/2" gaps between panels
ROOF NOTES

- R70 +/- Biggest Challenge - Main Roof!
- Simplest: 11 1/2” polyiso foam on air barrier but cost was killing us
- Front Section OK -12” Trusses - 50/50 mix of batt and foam, not much area
- Rear Section - 22” sloping trusses meant couldn’t get 50/50 ratio
- Energy Star 3.0 doesn’t allow suspending a batt - need contact on 6 sides
- Special calculations determine allowable 44% spray foam/56% fluffy ratio
- Then varied thickness to maintain ratio as truss sloped.
- Saved 60 - 70k.
- I don’t want to do this again!!! No easy, cost effective or elegant options…..
GARAGE NOTES

- R60 +/- Two rotated layers of R30 batts on suspended ceiling
- SIP Panel (R30) provides closure and continuity with exterior insulation above
- Insulation installers couldn’t grasp that the overlap had to occur in both directions

- Steel Columns: Potential major thermal break and needed 3d Therm modeling
- Soil conditions required a moment frame for seismic
- Multiple connections at columns created more breaks
- Interrupt column in insulation layer, add thermal isolation pad, then stub column
WINDOW NOTES

- u0.14/SHGC 0.36 (Limited South Exposure) - uPVC Tilt-Turn - Fixed/Operable
- Different Culture
  - ‘Bid’ not a fixed price but a list of quantities
  - Challenges with coordinating electric hardware
  - Clearing custom delay (1 month)
  - Websites don’t have the necessary information
- Large BR opening was value engineered from two small to one large
- Accessories such as screens not ‘standard’, sills are third party
- Good Pricing - Triple glazed u0.14 not much more than u0.28 fiberglass double
- Another Different Culture - Americans don’t like the tilt turns very much………….
VARIOUS
• Siga total system support and refining details with contractors
• Prefab framing added some gaps that weren’t in the shop drawings
• Attention to penetrations - CM & subs totally entered the spirit
ERU
- Daikon (2) 72 - 75% efficient
- Gas furnace coil prevents ‘draft’ complaints, is backup heat
- January -25F, heat pumps shut down, interior temp down 7F in 9 hrs.
- Not as efficient as desired, no real options that were easily serviceable

COLD CLIMATE HEAT PUMPS
- Mitsubishi ASHP for heating and cooling
- We did not fully account visually for 18” off roof requirement
- Client wanted two heads with separate T-Stats in each unit. Not a good idea............
- Using more electric than calculated
  Partially the 2 head - 2 Tstat situation
  PH design temp was (special permission for seniors) 72F, many set it at 77F.
  Still monitoring to work out these bugs.
THE NASTY BITS - SURPRISE, SURPRISE

THERMALLY BROKEN, FIRE RATED DOOR UP TO 2HRS
According to website, but shop drawings…….”Hey, we were just joking’

TRASH CHUTE - BIG HOLE IN BUILDING
Manufacturer zero interest - Two small fire rated doors are quite leaky

LAUNDRY GAS DRYER MAKEUP AIR - HOLE IN WALL
No commercial condensing, individual interlocked dampers

AIR SEALING BETWEEN UNITS - NOT JUST ENVELOPE
Passed. Better with minor extra attention at party/corridor.

TAKEAWAY
Exceed PH standard and then you can take a few hits and still certify
What did the Modeling Show?

PHIUS’ new Climate Specific Targets

<table>
<thead>
<tr>
<th>Specific building demands with reference to the treated floor area</th>
<th>Treated floor area</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>27690 ft²</td>
<td></td>
</tr>
<tr>
<td><strong>Space heating</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heating demand</td>
<td>4.66 kBTU/(ft²·yr)</td>
<td>71% of 6.6 kBu/(sq ft·yr)</td>
</tr>
<tr>
<td>Heating load</td>
<td>4.68 BTU/(hr·ft²)</td>
<td>92% of 5.1 Btu/(hr·sq ft)</td>
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<tr>
<td><strong>Space cooling</strong></td>
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<td></td>
</tr>
<tr>
<td>Overall specific, space cooling demand</td>
<td>0.94 kBTU/(ft²·yr)</td>
<td>50% of 1.9 kBu/(sq ft·yr)</td>
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<tr>
<td>Cooling load</td>
<td>2.24 BTU/(hr·ft²)</td>
<td>57% of 3.8 Btu/(hr·sq ft)</td>
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<tr>
<td>Frequency of overheating (&gt; 77 °F)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
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<tr>
<td><strong>Primary energy</strong></td>
<td>51.3 kBTU/(ft²·yr)</td>
<td>99.9% of 51.4 kBu/(sq ft·yr)</td>
</tr>
<tr>
<td>Heating, cooling, dehumidification, DHW, lighting, electrical appliances</td>
<td>17.3 kBTU/(ft²·yr)</td>
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<tr>
<td>DHW, space heating and auxiliary electricity</td>
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<td></td>
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<tr>
<td>Specific primary energy reduction through solar electricity</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Airtightness</strong></td>
<td>0.7 1/h</td>
<td>0.7 1/h</td>
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Cold Cash

Size
Conditioned, 10,000 sf garage not included

29,340 sf
PHIUS 27,836sf

Base Bid 5.39M $183 sf
Without Site 4.99M $170 sf
Delete Seismic 4.87M $165 sf

427k Upgrades 5.81M $198 sf
Without Site 5.41M $184 sf
Delete Seismic 5.29M $180 sf

Our market with garage amortized has been: $175 - $190 sf

COST

Key Cost Assumptions:
- Starting from high baseline
- Program includes cooling

Cathedral Square Calculations

<table>
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<tr>
<th>Incremental Construction Cost</th>
<th>Cost</th>
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<tr>
<td>Exterior insulation</td>
<td>$20,045</td>
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<tr>
<td>Roof insulation</td>
<td>$32,340</td>
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<tr>
<td>Upgrade windows &amp; doors (triple pane, Uwindow 0.13, R7.7)</td>
<td>$27,179</td>
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<tr>
<td>Mitsubishi hyperheat system for heating and cooling</td>
<td>$423,798</td>
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<tr>
<td>Delete hydronic heating system</td>
<td>($256,845)</td>
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<tr>
<td>Delete minisplits for cooling</td>
<td>($206,053)</td>
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<tr>
<td>Increased attention to air sealing</td>
<td>$23,137</td>
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<tr>
<td>Total</td>
<td>$63,600</td>
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Total PH Cost

<table>
<thead>
<tr>
<th>% of Total Const. Cost</th>
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</thead>
<tbody>
<tr>
<td>Incremental const. cost</td>
</tr>
<tr>
<td>Incremental architectural fees</td>
</tr>
<tr>
<td>PH modeling fees</td>
</tr>
<tr>
<td>PH certification</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
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Probably missing a few granular items - window bucks vs. flange etc.

Architect, MEP & PH consultant all donated time! Surprise, surprise.

MONEY, HONEY....
COMMON ROOM & LOBBY
LESIONS & CHALLENGES

- Surface/Volume of simple, large building easier to meet the model.

- Simple systems, exceed standard, take a few hits with the nasty bits: trash chute—ERV efficiency—fire rated doors - garage columns

- Foundation & Flat Roof Foam - All Foam - is always a challenge.

- Trust that a single ASHP head an Tstat is enough in a small unit.

- Visual impacts of ASHP & ERV - Take more care.

- Laundry make up air.

- Windows - Tilt turn, or…….

- Hydraulic Elevator Electric Usage - Traction becoming competitive
The phone rang. Cindy, Miranda and Katie from Cathedral Square. Do you have a minute to talk? Oh, boy, what I have done now? .............Pause. We’d like to add the bocce court & pergola.

BOCCE
Court & Pergola

07.21.17 PHIUS CERTIFICATION
2017 PHIUS AWARDS
Best Overall Project
Best Multi-Family
Honorable Mention Affordable Housing
This concludes The American Institute of Architects Continuing Education Systems Course

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