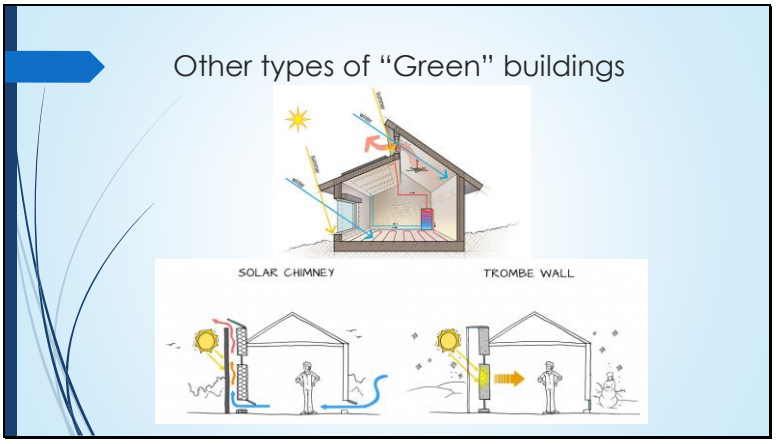
Slide 1

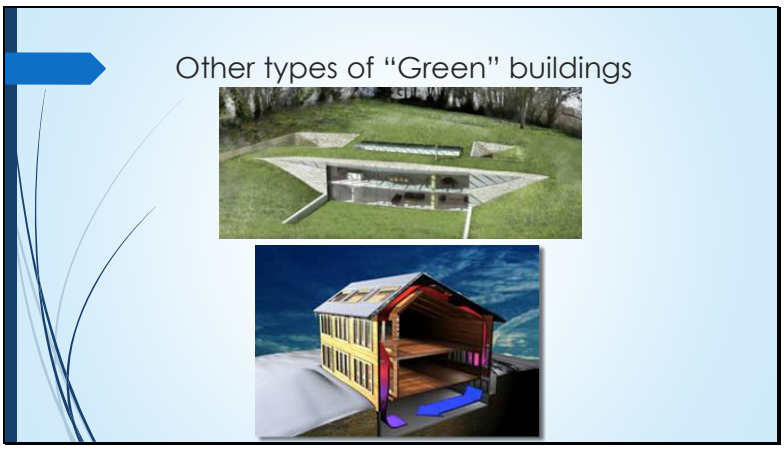
The Design, Construction, Testing and Lessons Learned RochesterPassiveHouse.blogspot.com

Slide 2



For every super efficient "green" project, there are plenty of examples of project downfalls - Earth Bermed, Passive Solar, Enertia, Thermal Massive, Geo Thermal, etc. They all have examples of not working the way they are intended.

Slide 3



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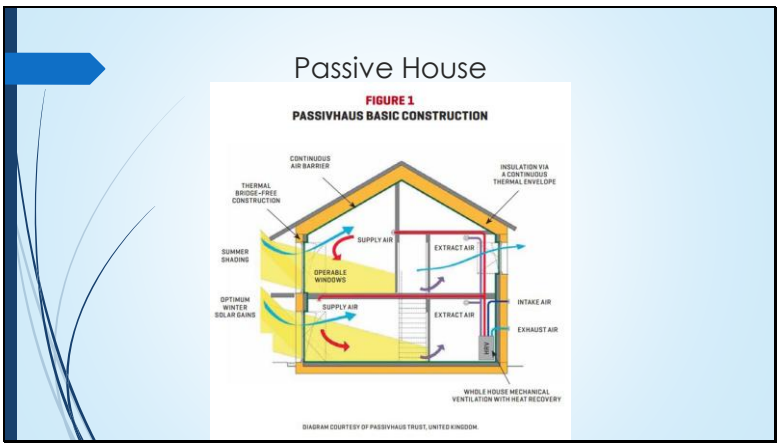
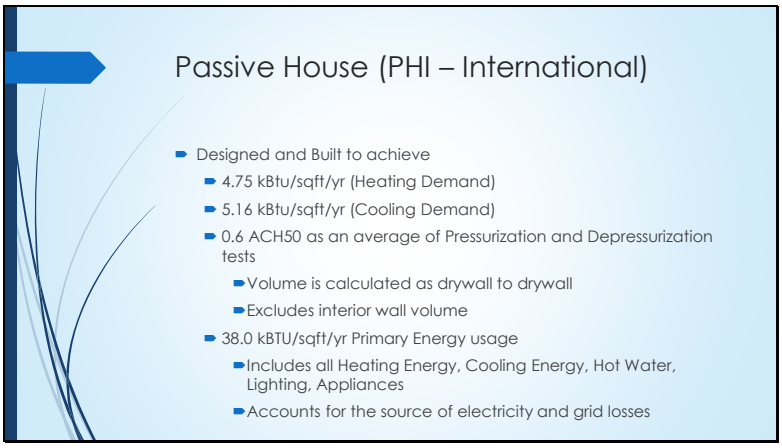


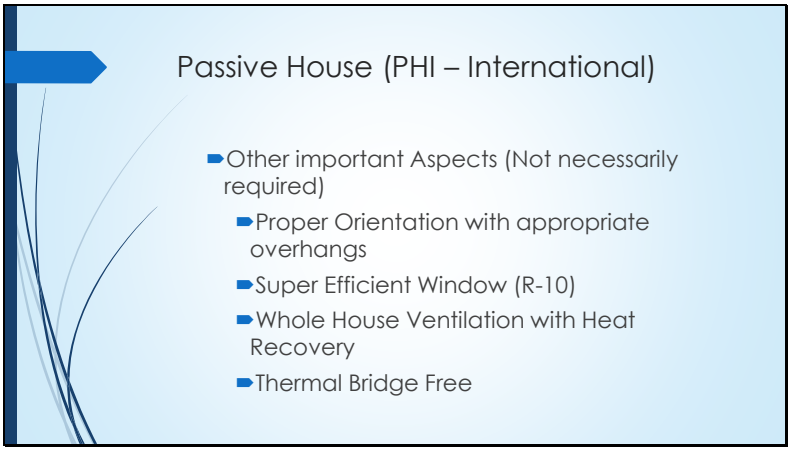
Passive House is the exception. There are over 50,000 in the world, and they ALL work the way they were intended. However the biggest deterrent is “It’s too expensive!”

Slide 5



These are the Passive House International Standards. The PHIUS Standards are slightly different and very much more due to specific climate data.

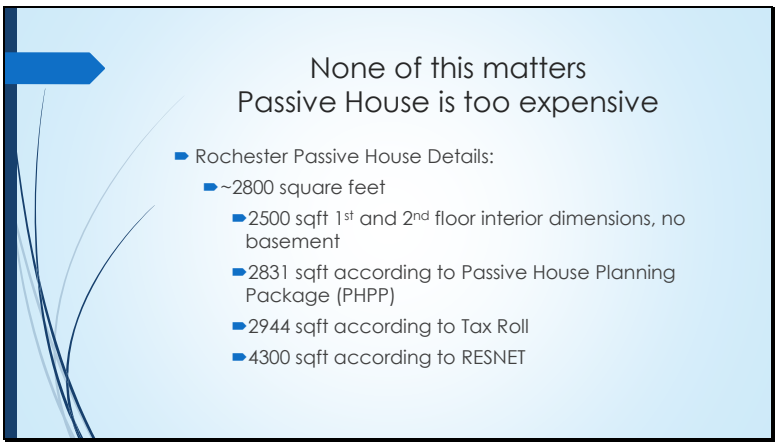
Slide 6



Other important items that will make a Passive House Project a success

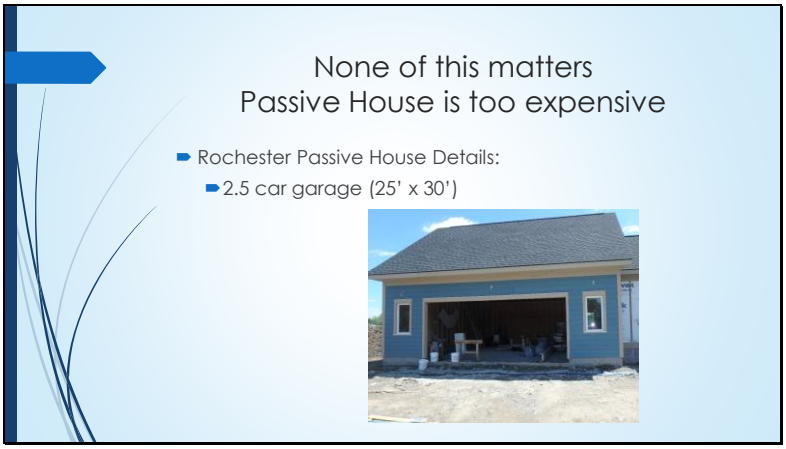
- Proper Orientation with appropriate overhangs
- Super Efficient Window (R-10)
- Whole House Ventilation with Heat Recovery
- Thermal Bridge Free

Slide 7



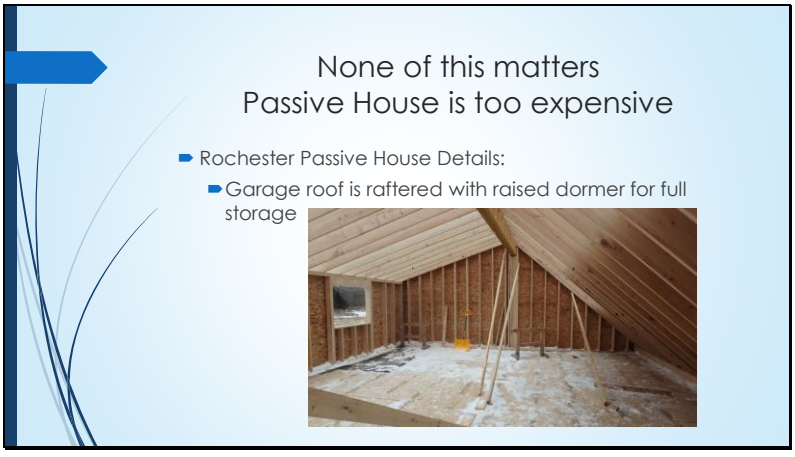
We will be looking at Rochester Passive House for a majority of this presentation. I like to start with the financials 1st to help keep you engaged in the process. The house is basically 2800 sqft – but it depends on who you ask

Slide 8



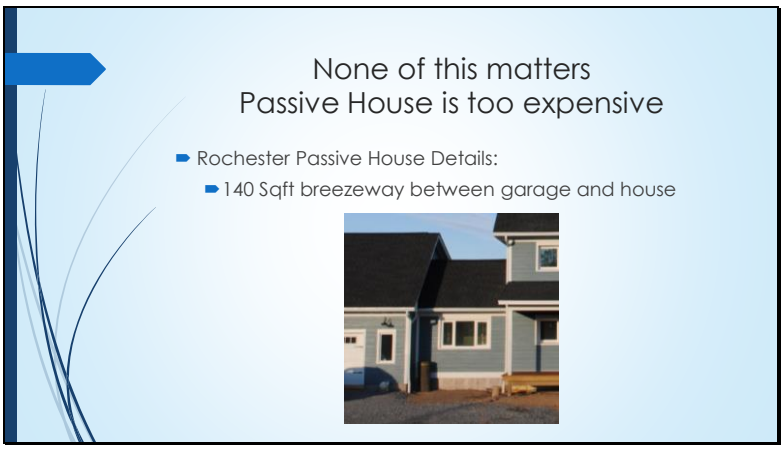
Here are some "extras" that are included in the cost of the project, but don't actually add to the living area of the home.
2.5 car garage

Slide 9



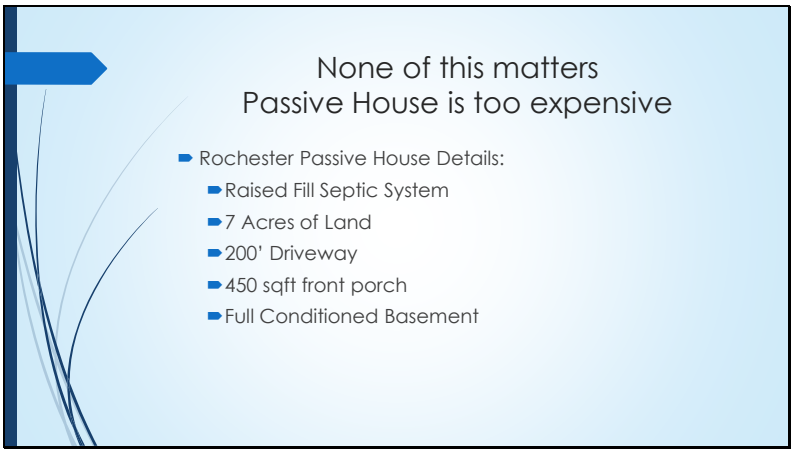
The area over the garage can be used for storage, or finished off in the future for extra guest space.

Slide 10



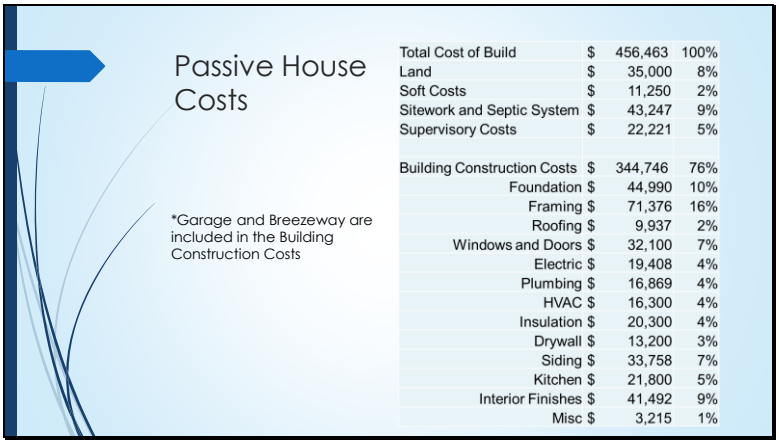
The breezeway helps add an air lock entry, and keep the garage attached to the house. Since Passive House doors are so heavy, they don't make them spring loaded – you'd lose a finger or 2. we needed the spring loaded fire door to have the garage attached to the house.

Slide 11



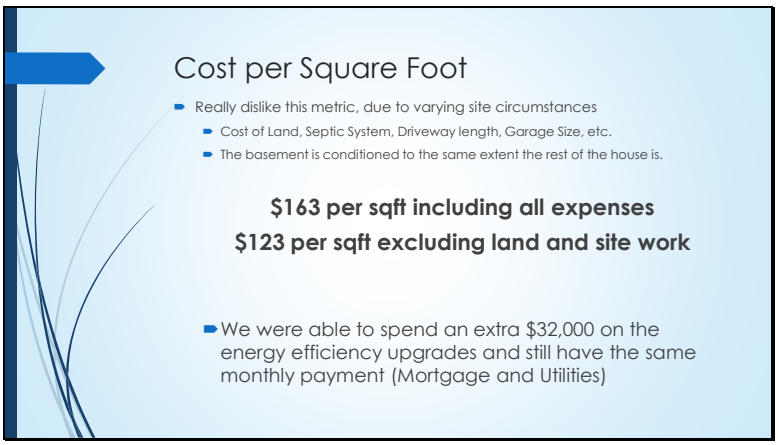
Misc site work can vary quite a bit from project to project. The basements of a Passive House are just as insulated as the rest of the house, so they really should be included in the sqft price of the house (we are only including about 60% of it for our numbers. The front porch aids to the shading of the windows, but is not required. Each passive house project is a little different.

Slide 12



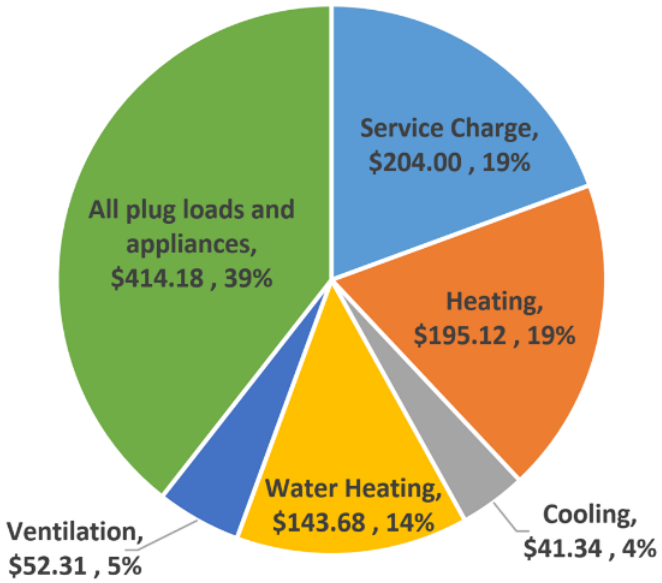
Even more potential savings:
Siding is LP smart side, not vinyl.
Amish Kitchen with quartz countertops
50 year laminate floors
Upgraded trim package

Slide 13



Really dislike this metric, due to varying site circumstances
Cost of Land, Septic System, Driveway length, Garage Size, etc.
The basement is conditioned to the same extent the rest of the house is.
$163 per sqft including all expenses
$123 per sqft excluding land and site work

Slide 14



Heating Energy for 2017 was 1919 kWh - $195
Cooling Energy for 2017 was 382 kWh - $41
Water Heating Energy for 2017 was 1381 kWh - $144
Ventilation Energy for 2017 was 498 kWh - $52
Our Service Charge ($17/month) was our largest expense
*Perspective – we spend more each month on cell phones than we do to heat our house ALL year

Slide 15

Rochester Passive House was built affordably, and with such low utility bills, there is not much difference in monthly payment. I should note, we are not in an area with Natural Gas – we'd be on propane, so that makes the "payback" even faster.

Slide 16

Rochester Passive House Technical Data

Basement Slab	R-38	8" of EPS Foam (2 layers of 4")
Basement Walls	R-62	13" AMVIC ICF + 2x4 walls 8" inside of ICF insulated with dense packed cellulose
Above Grade Walls	R-54	Double 2x4 wall construction with 8" space between walls insulated with cellulose
Windows	R-7 (U-0.14)	Zola UPVC tilt and turn windows
Attic Insulation	R-95	25" of settled open blown cellulose
Airtight Construction	48 CFM_{50} / 0.08 ACH_{50}	The equivalent leakage area for this house is less than a 2" diameter hole
Whole House Ventilation	ComfoAir 350	Up to 86% heat recovery ensuring full volume of air replaced with fresh filtered air every 3 hours
Heating / Cooling	2 x 9000BTU/hr Mr. Slim Heat Pumps	30.5 SEER, 13.5 HSPF – heat load calculation only requires 1, 2nd installed for redundancy
Water Heater	Sanden CO2 Heat Pump	COP 4.5, can supply over 1.5 hours of continuous hot water

Lots of insulation, Airtight Construction, very efficient heating, cooling and water heater keep the utility bills extremely low.

Slide 17

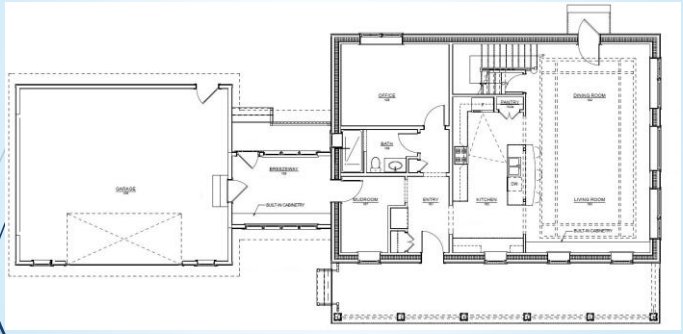
Design Optimization

- Simplify Floor Plan Shape
- Window Sizes and Orientation
  - Maximize Southern Exposure
  - Provide proper Overhangs
    - South overhang allow full shade in the summer and full sun in the winter
- Window Placement in Wall Assembly
  - Window installed in the middle of the R-Value of the wall

Use of Passive Solar techniques helps keep the house warm – but the sun doesn't always shine in Western NY.

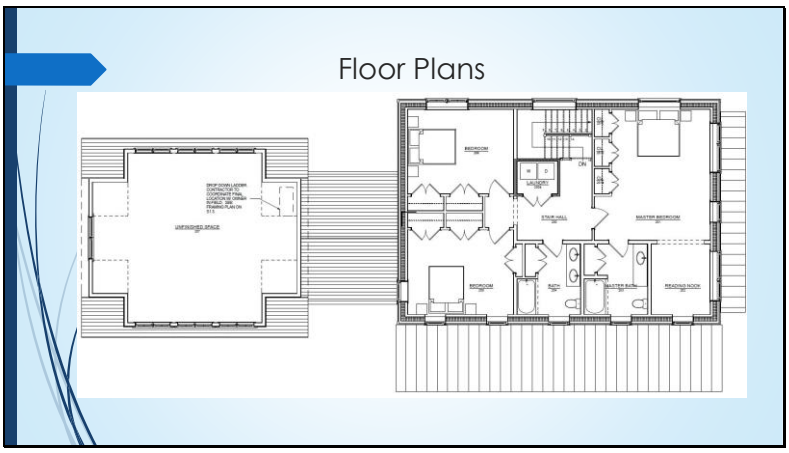
Slide 18

Floor Plans



Simple shape, open floor plan, nothing out of the ordinary. Possible 1st Floor master by transforming the office into a bedroom.

Slide 19



3 large bedrooms, 2nd floor laundry – with the use of a ventless dryer. 2 full 2nd floor bathrooms.

Slide 20

Front of the house faces due west. Smaller windows, lots of shading where possible to help control the solar gain from the west. We also had the windows glazed for a SHGC for 0.3 on the west side of the house.

Slide 21

South side of the house has 24” overhangs on the 2nd floor and 36” overhang on the 1st floor for summer shading.

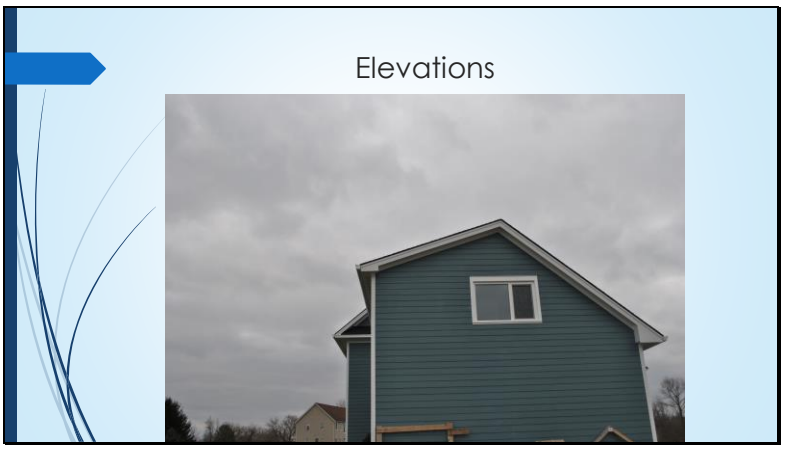
Slide 22

Maximized southern exposed glass. The SHGC of these windows in 0.6 – while the glass is also an R-11. 1st floor windows are taller (thus the larger overhang).

Slide 23

The back of the house faces east. These windows are glazed with R-11 Glass and a SHGC of 0.3. Facing east, not much can be done regarding exterior shading.

Slide 24

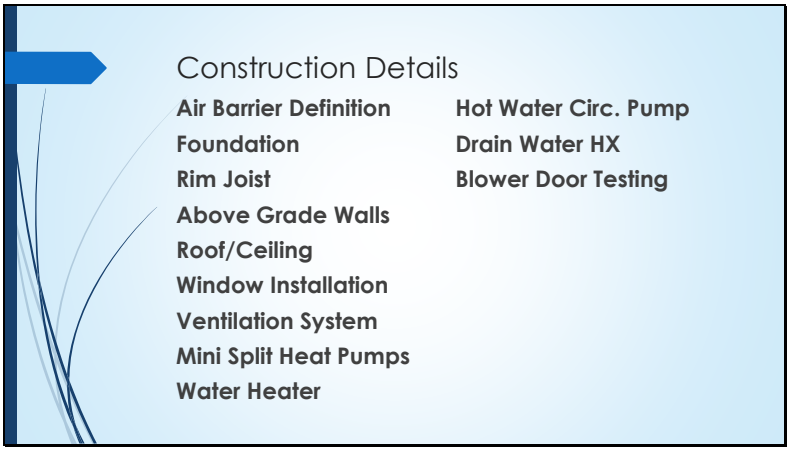


Back of the garage has a full dormer for storage, and the Passive House window on the gable end.

Slide 25

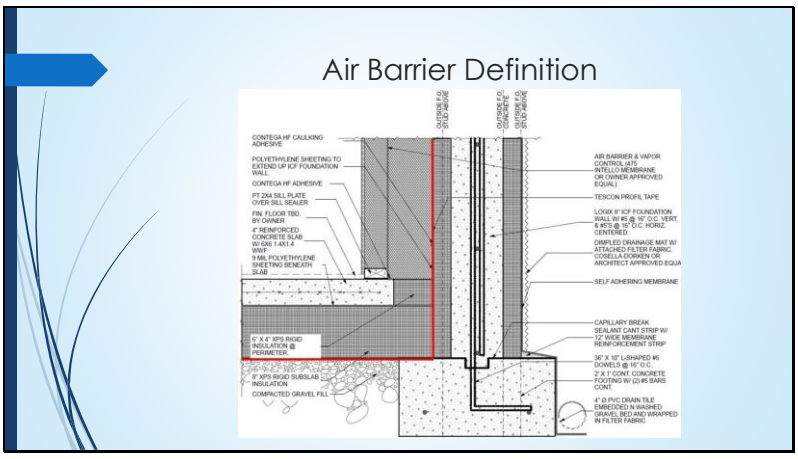
North Side of the house has minimal glass (only for egress).

Slide 26



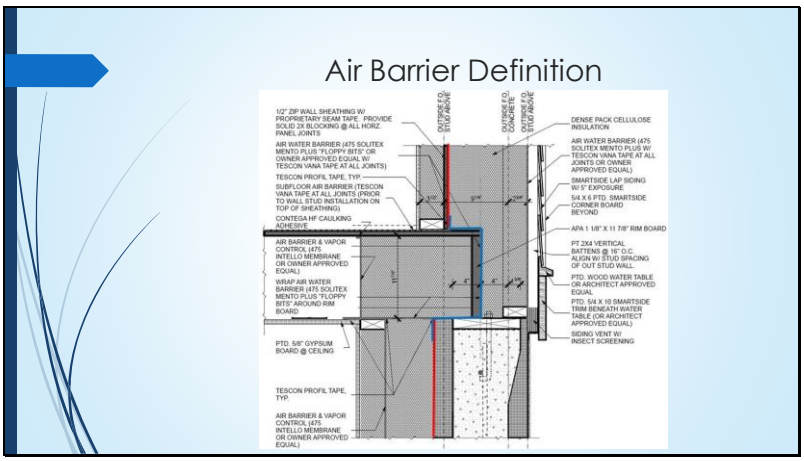
There is quite a bit of detail with all of the exterior aspects of the house we will go into, as well as the mechanicals of the house. Airtightness must be designed into the house. The redline exercise is very important. Once it is defined on paper, we can implement it in the field. “How are we connecting the air barriers together?”

Slide 27



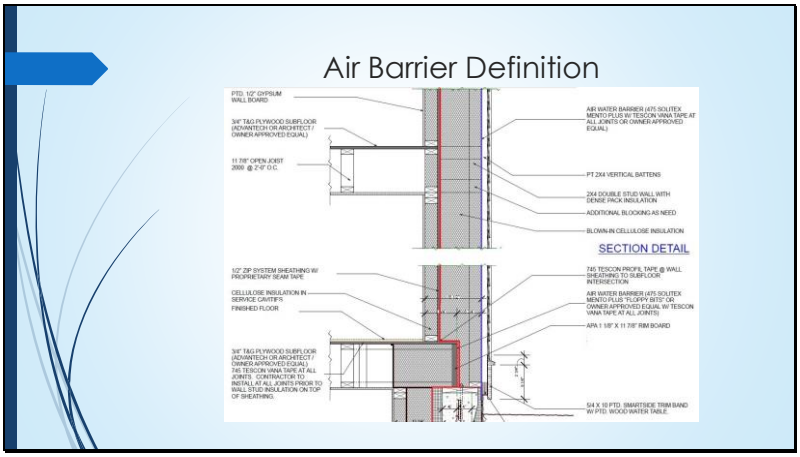
Sub slab radon barrier is sealed to the inside face of the ICF foundation

Slide 28



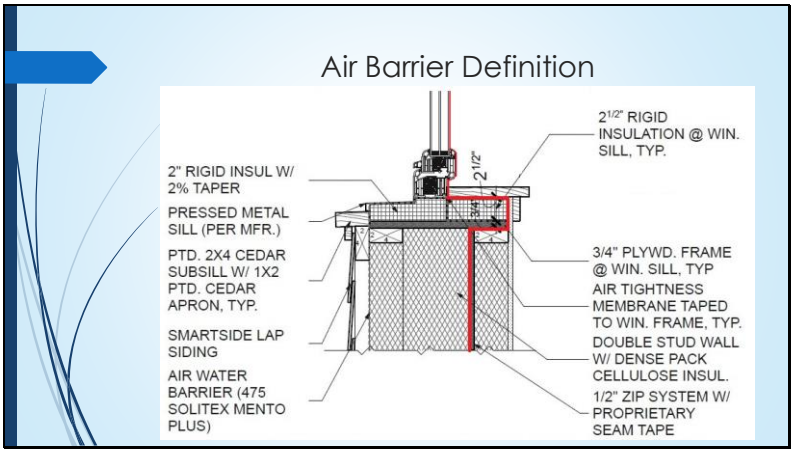
A floppy bit was installed prior to setting our 1st floor deck. This piece of fabric can be connected at a later time to other air barriers.

Slide 29



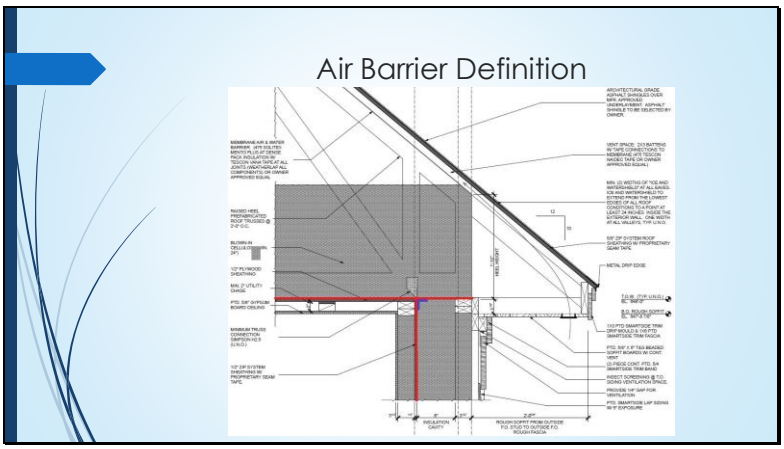
Interior wall is load bearing. The sheathing on the interior wall is our air barrier. This was chosen because is it protected from holes – either from the siding installation or from drywall installation. Keeping the air barrier intact is critical.

Slide 30



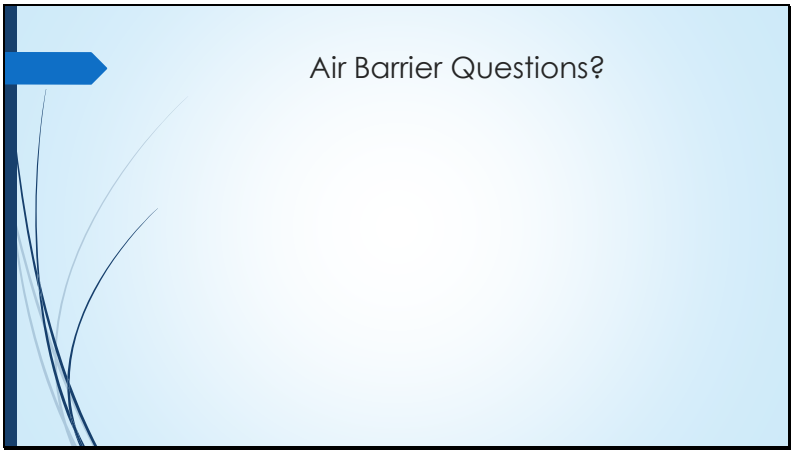
Window installation detail, connecting the air barrier to the window frame is very important

Slide 31



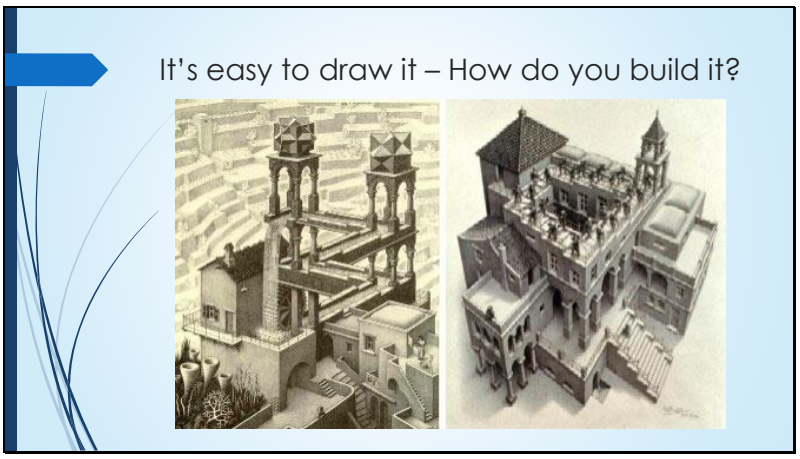
Above grade wall to 2nd floor ceiling connection. Again the air barrier is protected from future holes in drywall (adding light fixtures, etc.)

Slide 32



We will go into much more detail on each of these, This was to show you the red line exercise we did in the design phase of the project.

Slide 33



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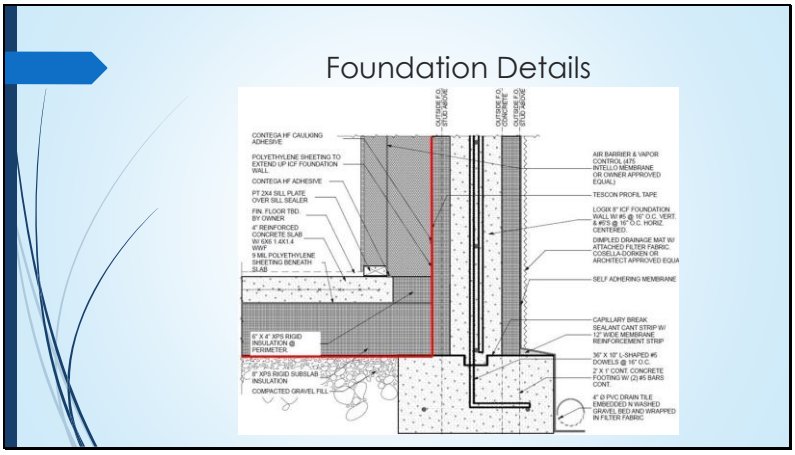
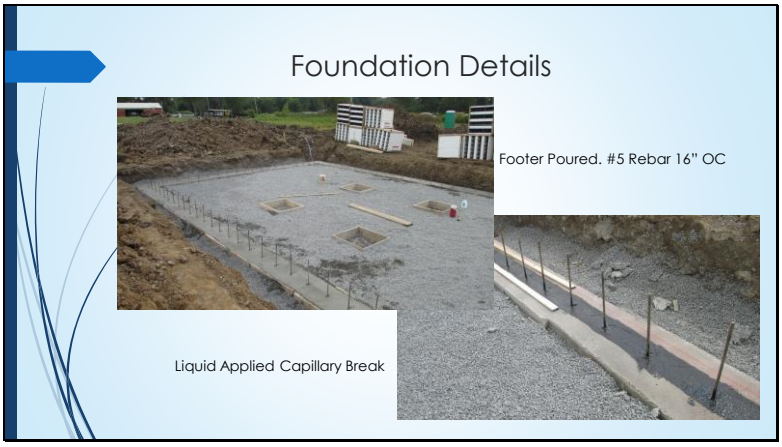
Slide 34



Slide 35



Slab prep

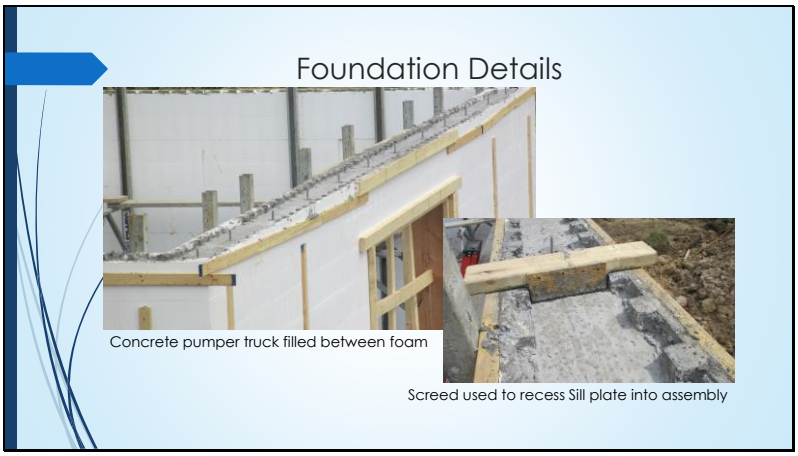
Slide 36

ICF assembly

Slide 37

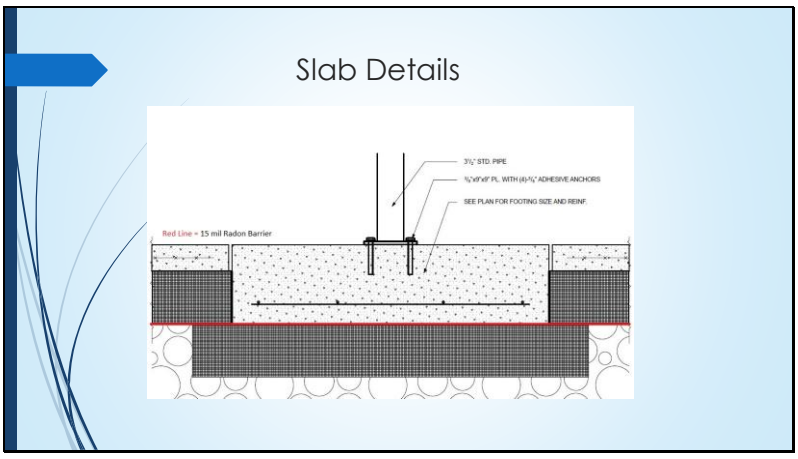
Pre-concrete scaffolding

Slide 38



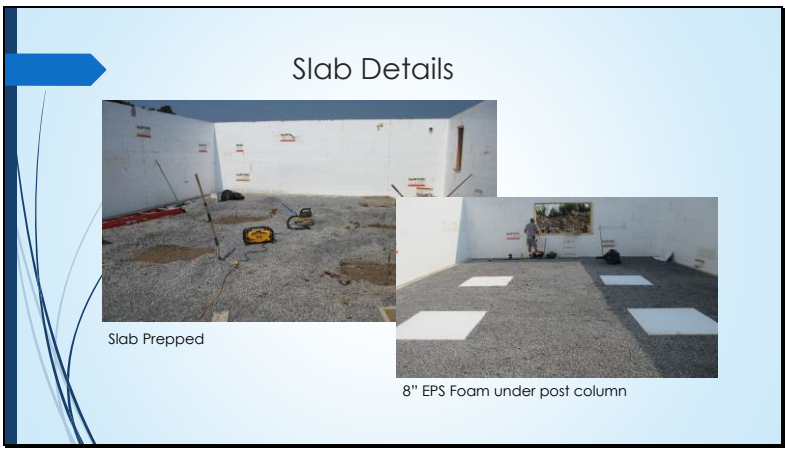
Standard ICF construction

Slide 39



Sub slab air barrier. Keeping it simple!

Slide 40



Prepped for slab pour with crushed stone, added 8” of EPS foam under post location. The EPS foam used has a compressive strength of 40 PSI (5760 PSF) – Assumed soil bearing pressure is 3000 PSF.

Slide 41

Radon Barrier laid flat

Slide 42

8” EPS foam laid down sub slab. Post column frame made out of foam. This will help minimize “floating the foam”.

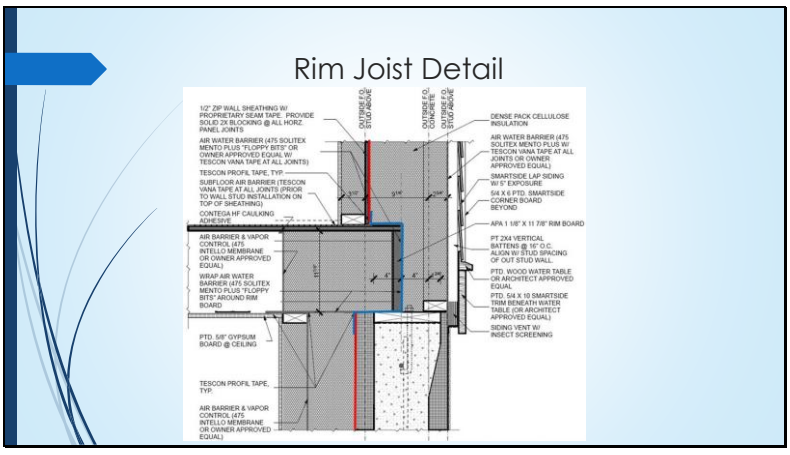
Slide 43

Slab edge insulated with 8” of EPS foam plus R-20 ICF.

Slide 44

Steel Beam pocket insulated with rigid foam – R-25.7 to the outside of the steel

Slide 45



Rim Joist detail – floppy bit installation

Slide 46

Belt and suspenders – acoustical sealant, sill plate gasket, acoustical sealant.

Slide 47

PT sill plate then the floppy bit fabric.

Slide 48

1st floor deck set on top of floppy bit. Rim board installed

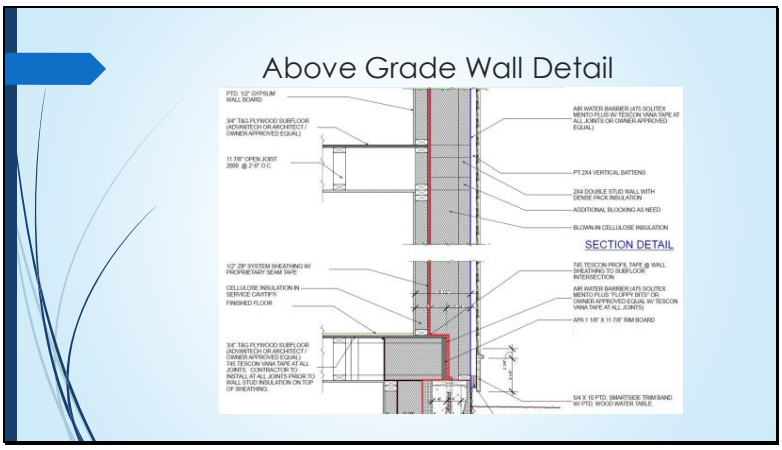
Slide 49

1st floor AGW built and floppy bit flopped up over rim board.

Slide 50

Floppy bit sealed to above grade wall air barrier and to foundation wall air barrier.

Slide 51



Above grade double wall assembly

Slide 52

Sheathed over windows and door and built an airtight box

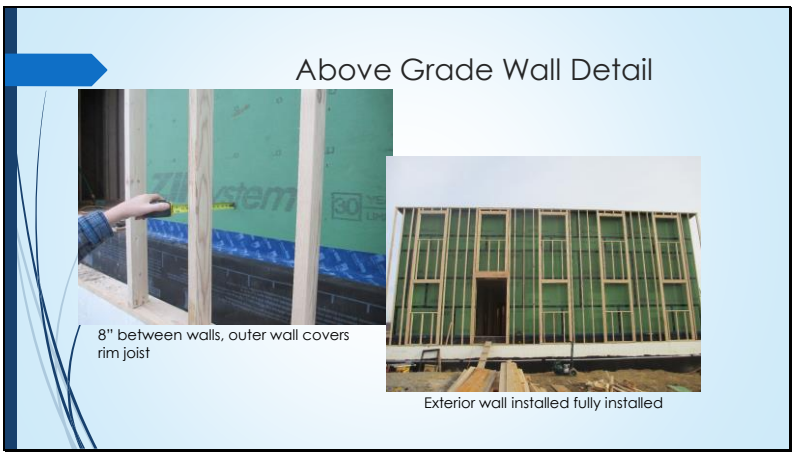
Slide 53

Zip system, all seams taped

Slide 54

Gusset installed at the top of the 2nd floor wall to tie the inner and outer walls together. Outer Wall built

Slide 55

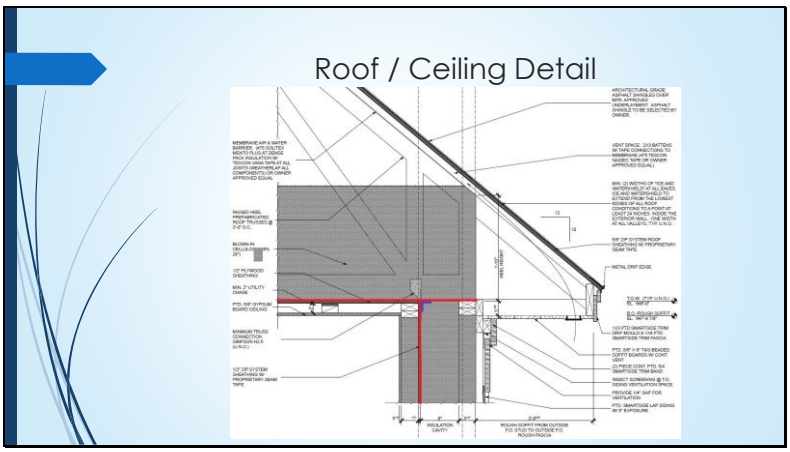


Outer wall covers the rim joist, and sits on the foundation wall. All of the RO for the windows are framed in the outer wall.

Slide 56

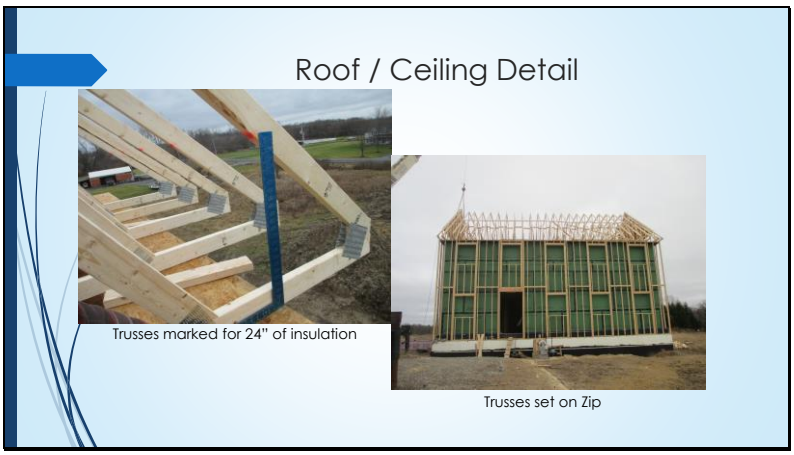
8” space between walls – to be insulated with dense packed cellulose. Gussets tie the walls together.

Slide 57



Time for the truss installation

Slide 58

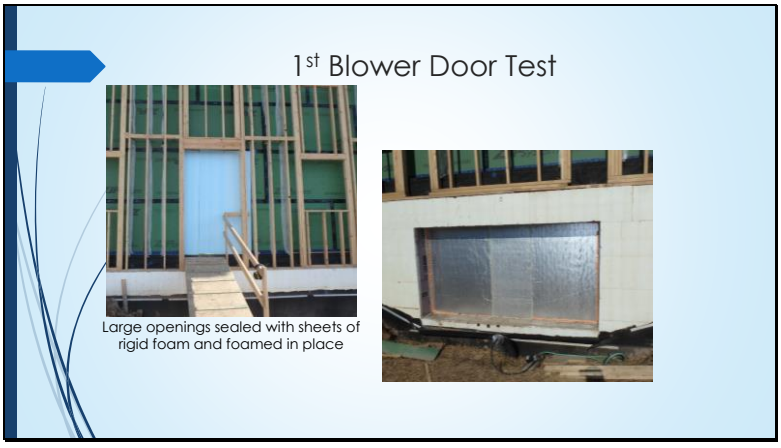


Trusses sit on the zip system gusset. We have over 24” at the outside edge of the outside wall to ensure our continuous thermal envelope.

Slide 59

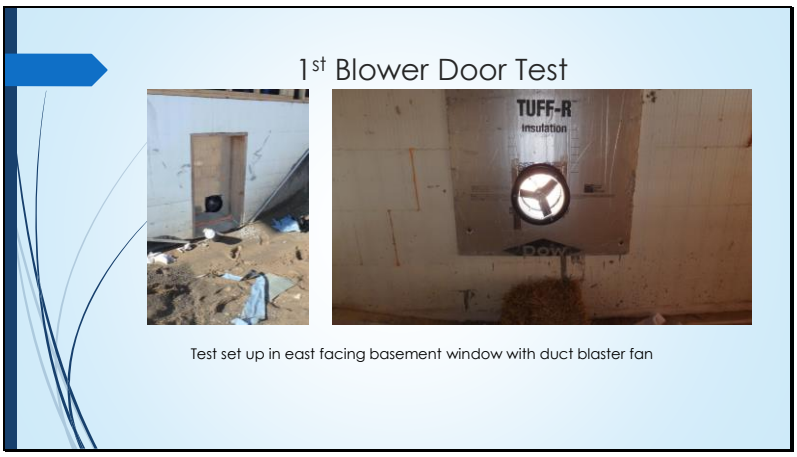
Hurricane straps would be problematic with an OSB ceiling – we used the Timberlock screws. Much Faster and Easier! After the roof was on, we sheeted the ceiling with Zip and tape all seams.

Slide 60



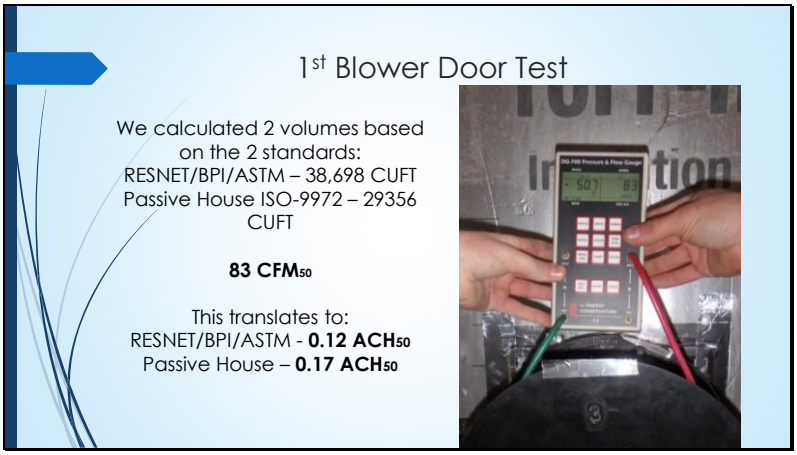
1st Blower Door prep – sealed all openings with rigid foam prior to test

Slide 61



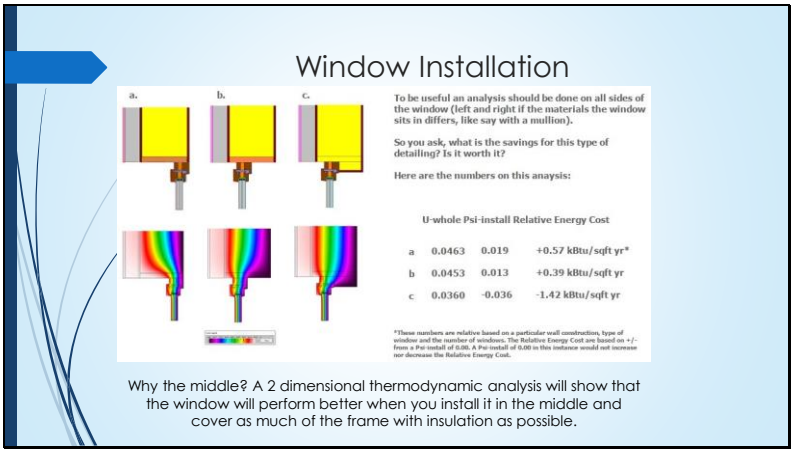
Used the duct blaster fan in a basement window for test

Slide 62



83 CFM50 – well under passive house airtightness requirements. This was our goal, since we will only be putting holes in the air barrier from this point on.

Slide 63

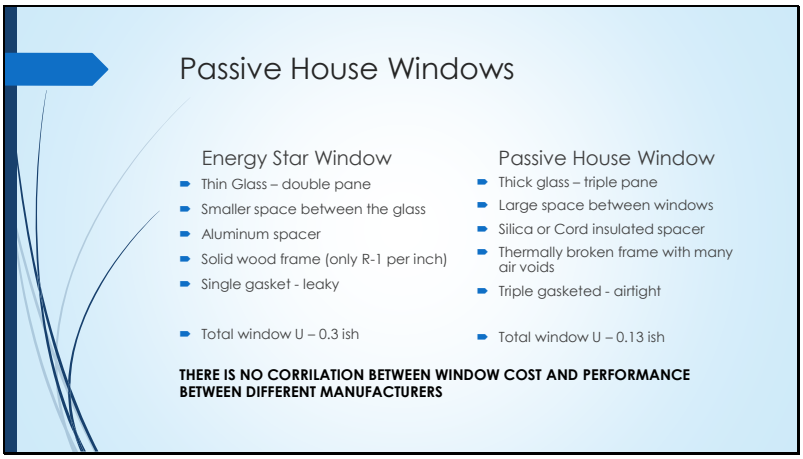


Window installation optimized. We put the window in the middle of the wall assembly, and insulated as much of the frame as possible to make sure the window would perform better than normal

Slide 64

There is a noticeable difference in the construction of the windows! The window on the left is an Energy Star Rated Window, the window on the right is a Passive House Window

Slide 65

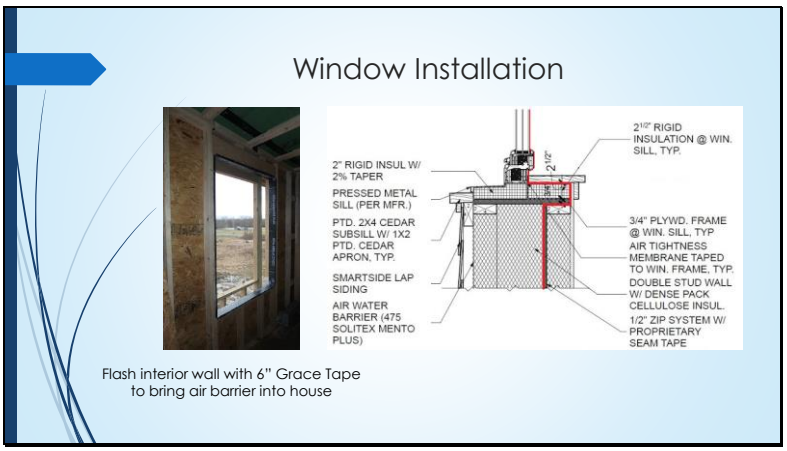


Some of the differences between the windows – bottom line – I got quotes that varied as much as $70,000 – and the most expensive was NOT the best performing.

Slide 66

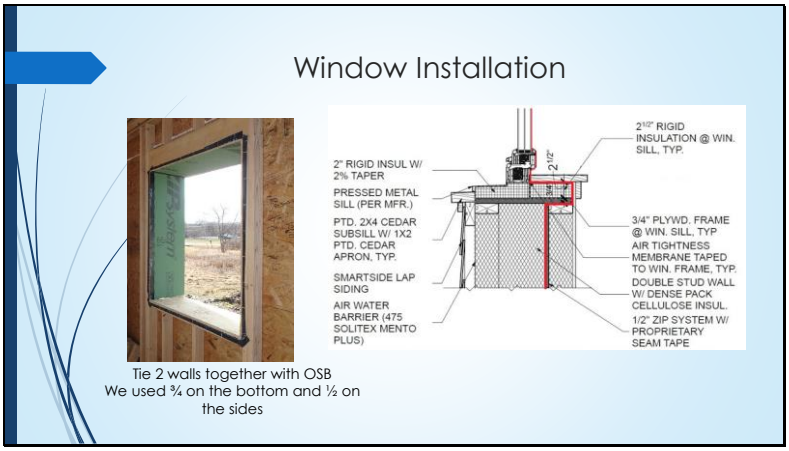
We cut the sheathing back, and all of the window RO's lined up!

Slide 67



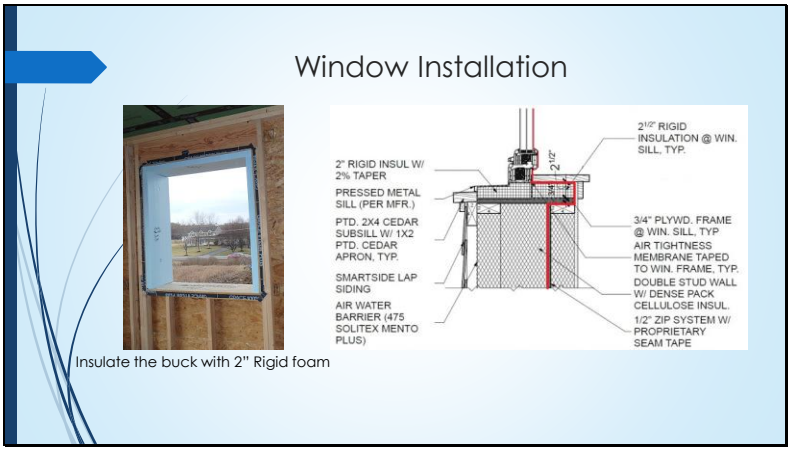
We prepped each window opening to ensure a continuous air barrier connection. We brought the air barrier to the inside face of the inside wall with flashing tape

Slide 68



Now we connected the walls with solid scrap OSB. For the bottoms we used ¾” due to the weight of the windows

Slide 69



We insulated the window buck with 2” XPS foam

Slide 70

We tapered the bottom foam to allow for drainage.

Slide 71

We covered the foam in our weather resistant barrier.

Slide 72

Now we installed shims on the bottom where necessary. Installed our stop blocks and set the windows in place

Slide 73

We planned to ½" gap to allow us to adequately foam the window to the RO.

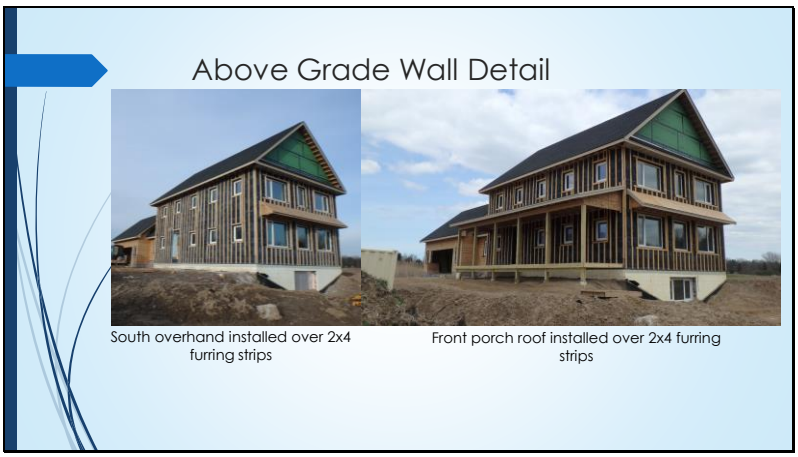
Slide 74

Then we sealed the window to the weather resistant barrier and the weather resistant barrier to the flashing tape we installed in step 1.

Slide 75

With the windows installed, we can finish our above grade wall assembly. We covered the exterior framing with our weather resistant barrier, and installed 2x4 furring strips over that to hold it in place

Slide 76

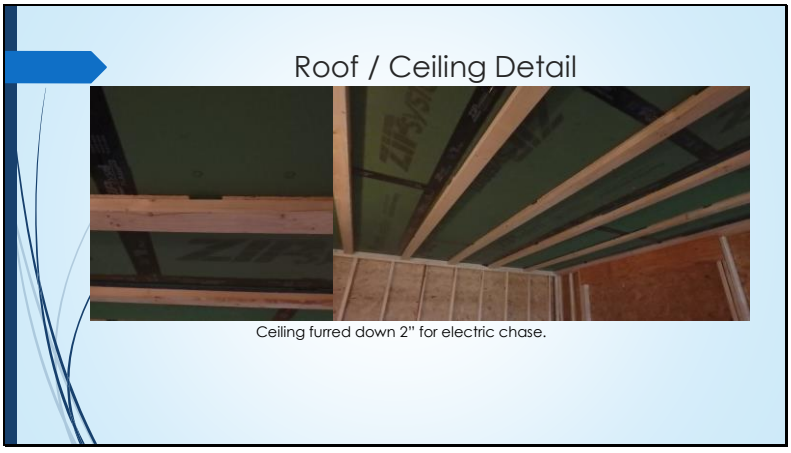


Now we added the overhangs and front porch roof. We have a complete thermal break between the roofs and the structure of the house. With all of this installed we insulated the wall assembly with dense packed cellulose.

Slide 77

Siding installation over the furring strips after the insulation was completed

Slide 78

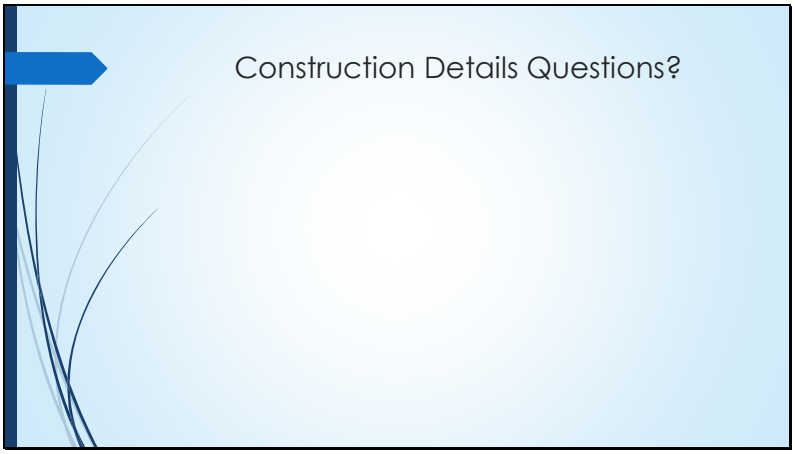


We furred down the 2nd floor ceiling 2” to allow an electrical chase and overhead lighting

Slide 79

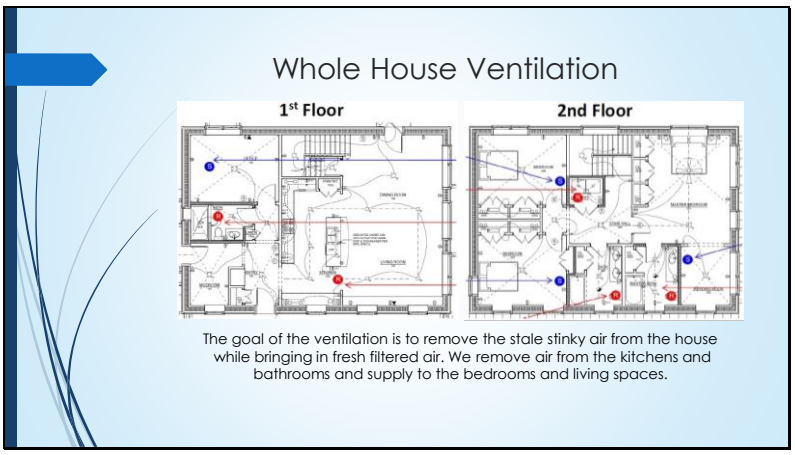
There are 2 penetrations in the 2nd floor ceiling – 1 plumbing stack sealed with a rubber gasket and a coax cable to an HD antenna in the attic – also sealed with a rubber gasket. All of our lighting is surface mounted – and the "recessed lights" we used fit in standard junction boxes.

Slide 80



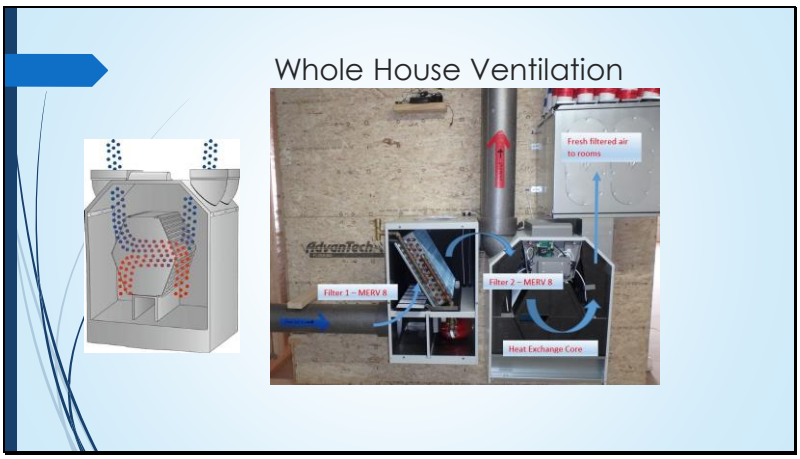
We just covered quite a bit of stuff. We will be going into the mechanicals next.

Slide 81



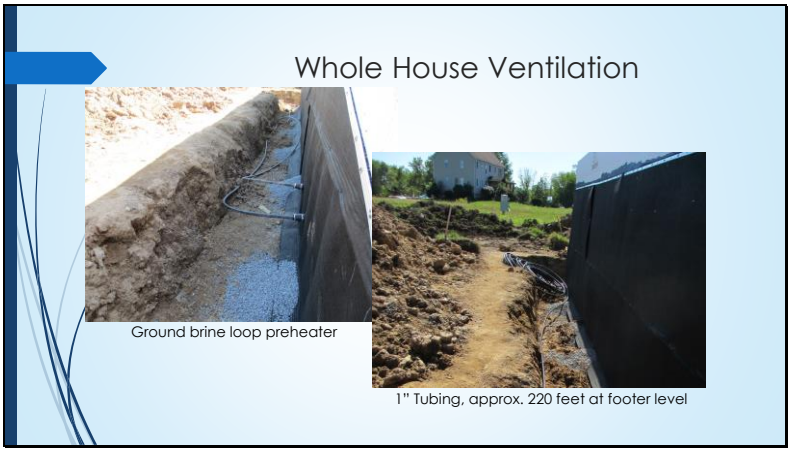
The goal of passive house ventilation is to ensure optimal indoor air quality while maintaining comfort and energy efficiency. Typically we want to exchange all of the air in the house every 3 hours. We bring in fresh filtered air and exhaust the stale stinky air. This is done with heat recovery to ensure we maintain the indoor air temperature.

Slide 82



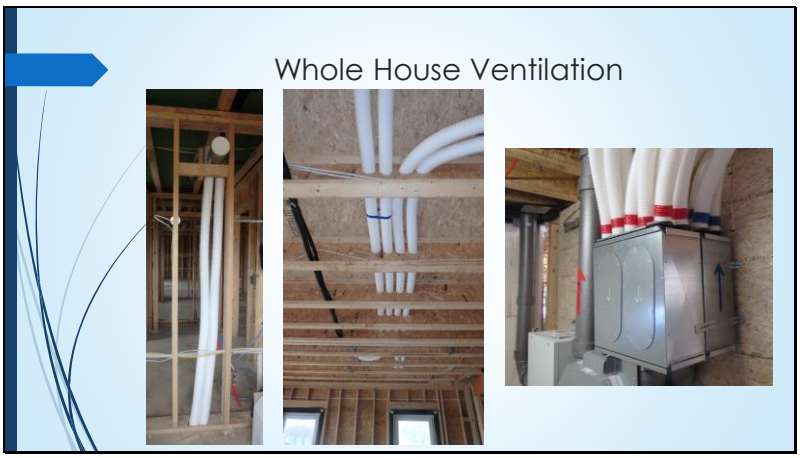
Air enters the ground loop heat exchanger where it is heated to 40 degrees. Then it goes into the air to air heat exchanger where it is heated to 66-68 degrees utilizing a cross counter flow heat exchanger. The outgoing air is thus cooled off keeping the heat inside the house.

Slide 83



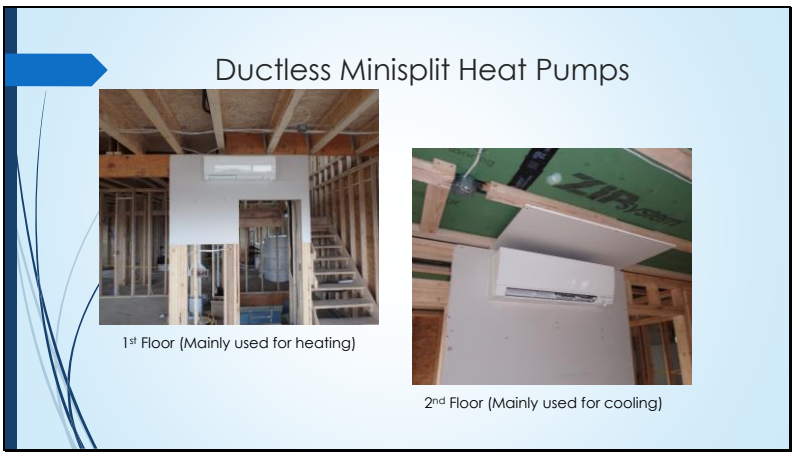
The optional geothermal loop will help temper in the cold winter air before it goes to the air to air heat exchanger and will provide dehumidification in the summer. We can get roughly a half ton of cooling for the electrical load of about 25 watts. - around 240 SEER

Slide 84



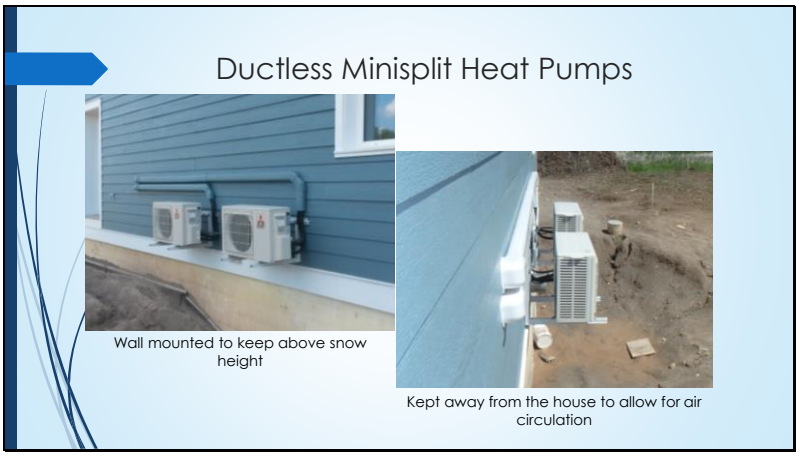
Air is distributed throughout the house with 3” tubes (all home runs) providing roughly 12 CFM per tube. Low air flow translates to low energy use, draft free and optimal mixing of air.

Slide 85



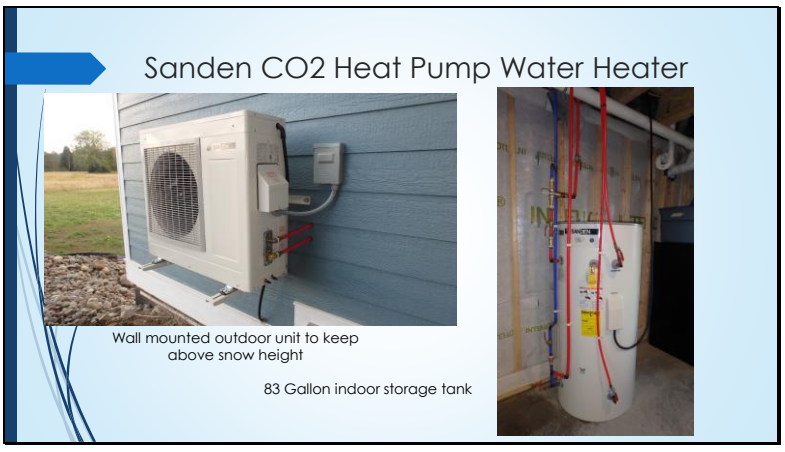
We installed 2 9000 BTU/hr mini split heat pumps. For the multi heat units we have noticed that the efficiency drops off, so we went with 2 separate units – which also provides for redundancy. At the time we were building the 6000 BTU/hr units were just beginning production.

Slide 86



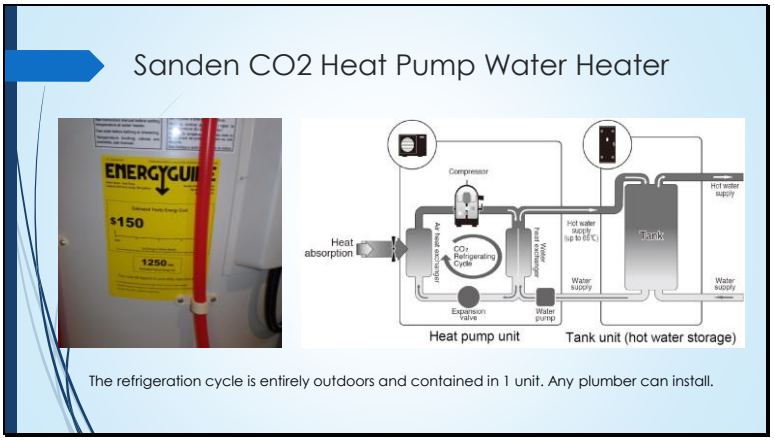
We mounted them up on the wall to keep free of snow loads.

Slide 87



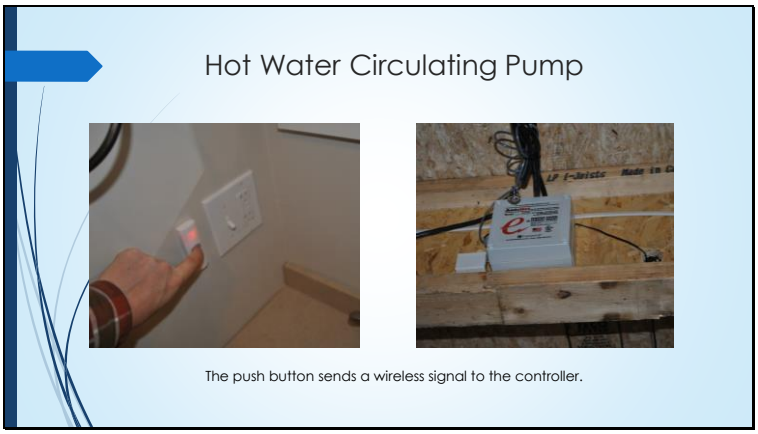
The water heater is a split heat pump. A standard heat pump water heater would double the heat load for the house – as the byproduct of the heat pump water heater is air conditioning.

Slide 88



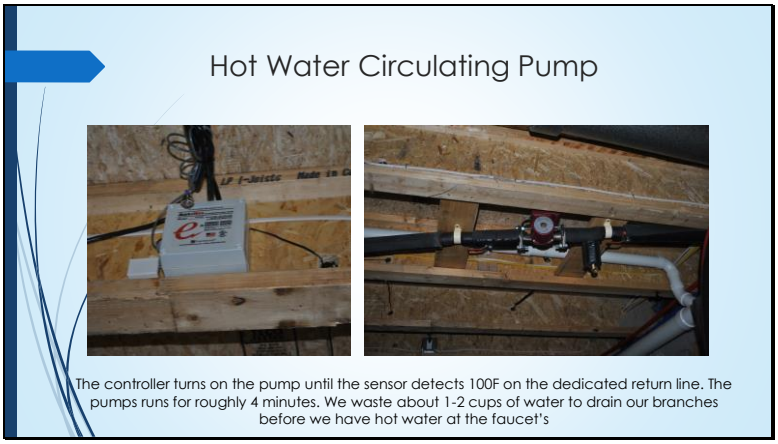
It is extremely efficient, and fairly simple to install. The heat pump heats water up to 160 degrees F and pumps it to the storage tank. At the outlet of the storage tank is a mixing valve. With 83 Gal of 160F water and a decent recovery efficiency we can supply a single shower with 1.5 hours of hot water (more when you use low flow heads and drain water heat recovery).

Slide 89



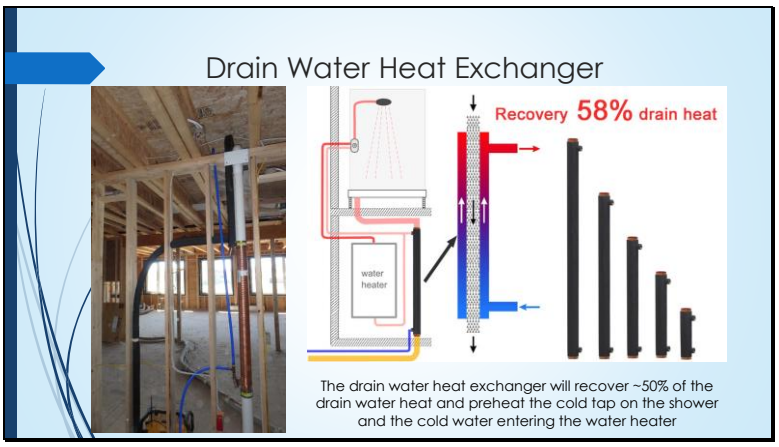
The circ pump was installed because of the distance between the master bedroom and location of the water tank. It also makes the water heater that much more efficient. When you drain the cold water from a the faucet – the water in the tank is replaced with street temperature water (about 40-50 degrees). When you turn on the circ pump, the water in the loop is roughly 70 degrees. You water heater doesn't have to work as hard.

Slide 90



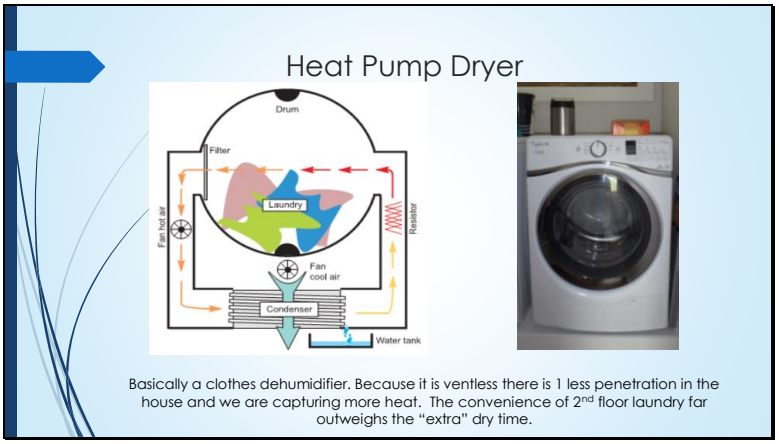
The amount of water wasted is much less also – it relieves a lot of stress on the septic system.

Slide 91



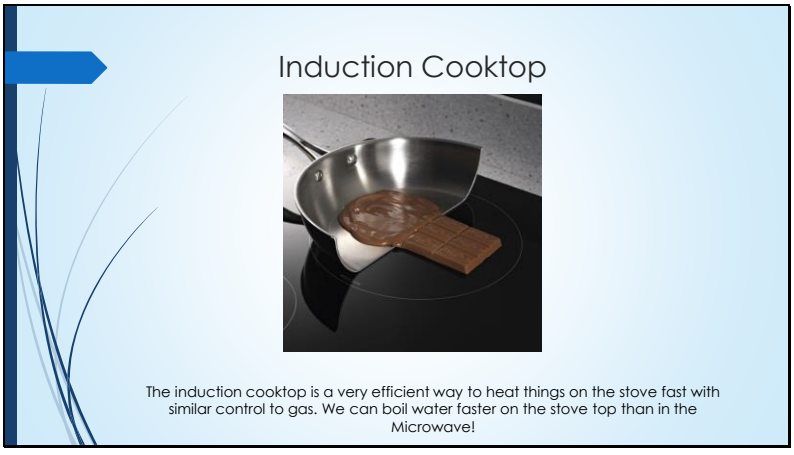
The drain water heat exchanger is another way we can temper the water before it enters the hot water heater. It only works when you are draining and drawing at the same time (showers). But the cold water at the shower mixing valve is warmer, so you don't use as much hot water. The water entering the tank is also much warmer.

Slide 92



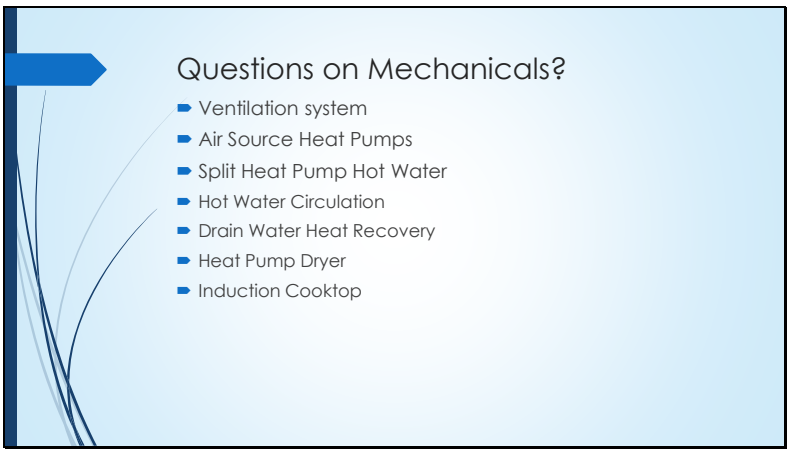
This is a whirlpool model – it is a full sized model. There are starting to be more and more brands going in this direction. This is also the beginning of "Washer and Dryer Combo" units.

Slide 93



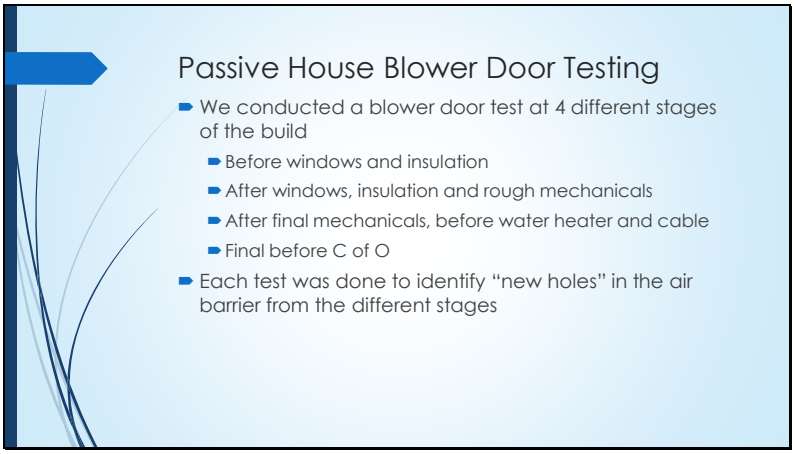
So far we love the induction cooktop – we can boil water faster on the stove top than in the microwave, we have the same control and reaction time as gas and when something boils over on the stove, nothing gets crusted into the top – because it is still cool.

Slide 94



Questions?

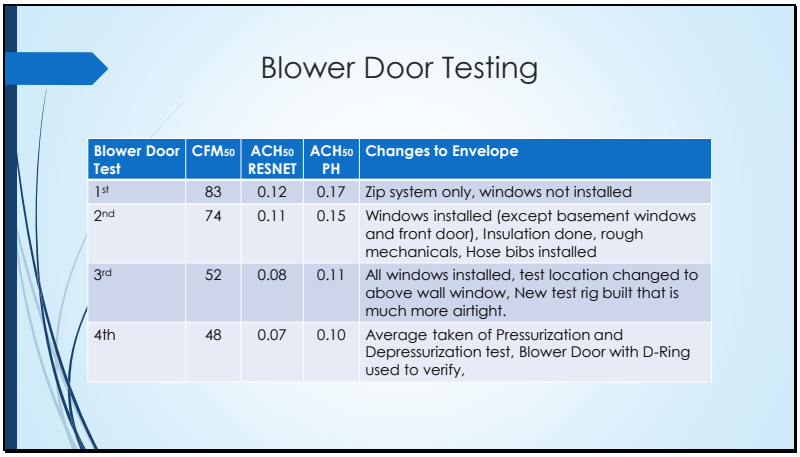
Slide 95



Blower door testing is vital at multiple stages of the build to help identify leaks before you can't find them anymore. 0.6 ACH50 is VERY tight.
We conducted a blower door test at 4 different stages of the build

Before windows and insulation
After windows, insulation and rough mechanicals
After final mechanicals, before water heater and cable
Final before C of O
Each test was done to identify "new holes" in the air barrier from the different stages

Slide 96



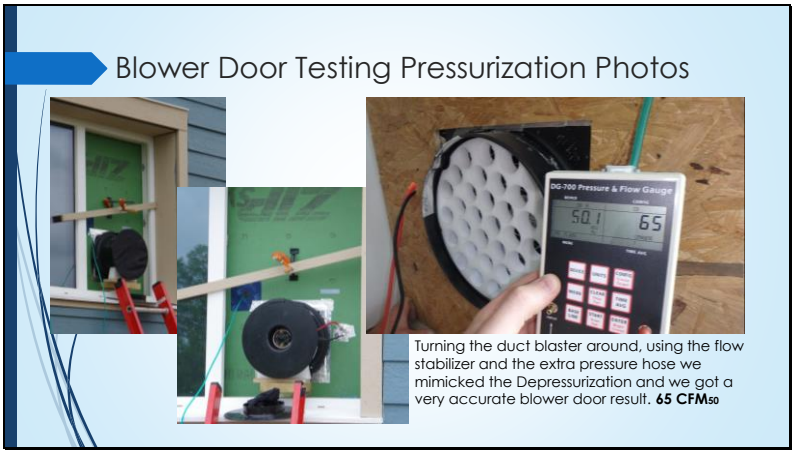
Blower Door Test	CFM_{50}	ACH_{50} RESNET	ACH_{50} PH	Changes to Envelope
1st	83	0.12	0.17	Zip system only, windows not installed
2nd	74	0.11	0.15	Windows installed (except basement windows and front door), Insulation done, rough mechanicals, Hose bibs installed
3rd	52	0.08	0.11	All windows installed, test location changed to above wall window, New test rig built that is much more airtight.
4th	48	0.07	0.10	Average taken of Pressurization and Depressurization test, Blower Door with D-Ring used to verify,

Blower door testing results at various stages

Slide 97

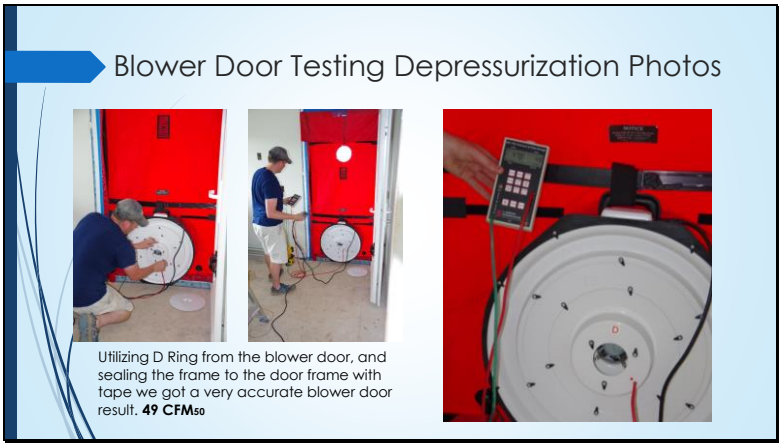
Depressurization set up.

Slide 98



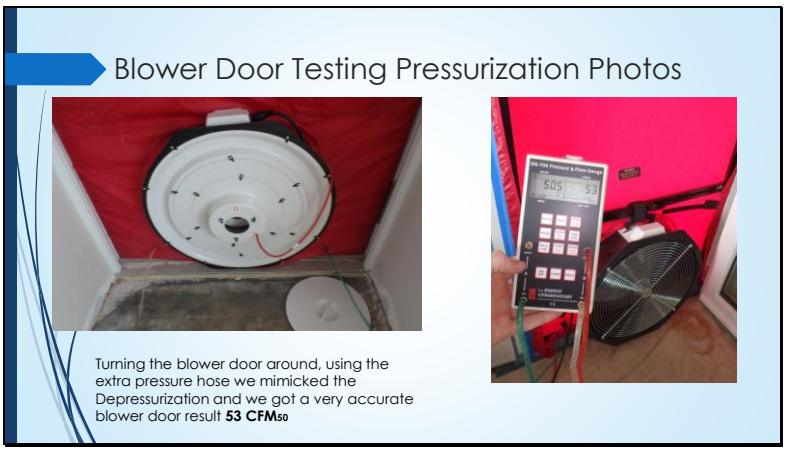
You can see the outside frame has not been fastened with the screw blocks. Oddly enough getting the assembly to be installed airtight was the hardest part – and it made a measureable difference. Once we did that we got the test down to 47 CFM50

Slide 99



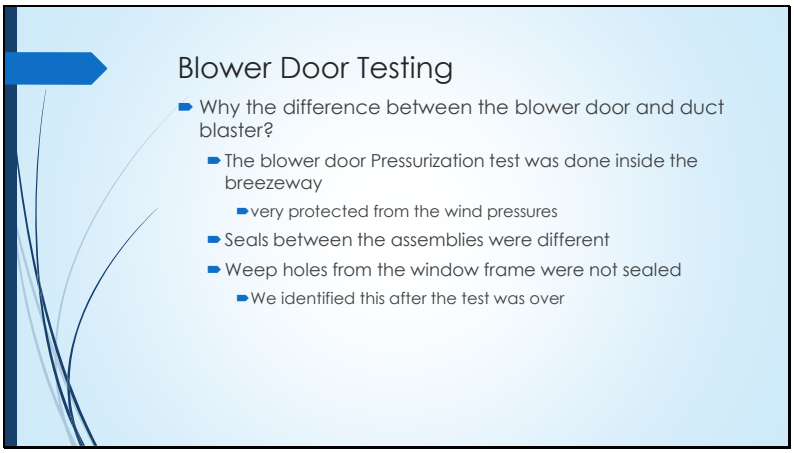
Utilizing D Ring from the blower door, and sealing the frame to the door frame with tape we got a very accurate blower door result. **49 CFM50**

Slide 100



Turning the blower door around, using the extra pressure hose we got almost the same result as the Depressurization test. **53 CFM50**

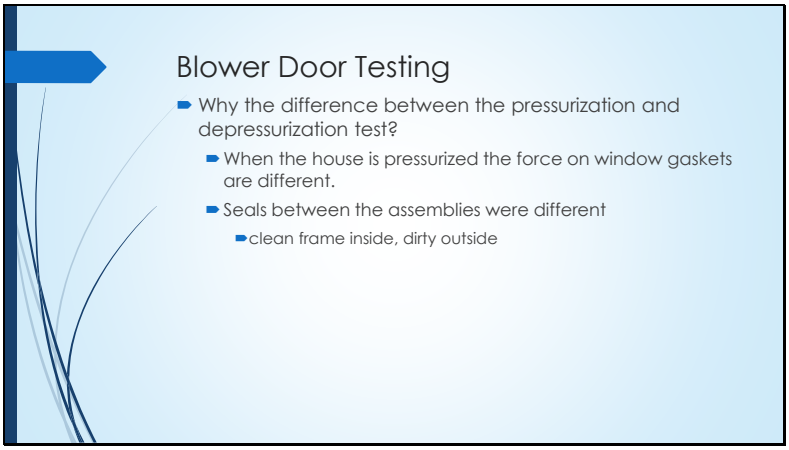
Slide 101



Why the difference between the blower door and duct blaster?

- The blower door Pressurization test was done inside the breezeway which is very protected from the wind pressures
- Seals between the assemblies were different
- Weep holes from the window frame were not sealed
  - We identified this after the test was over

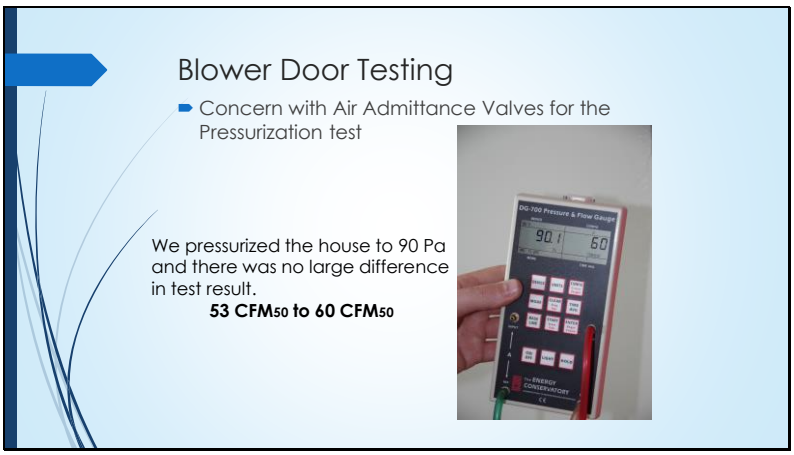
Slide 102



Why the difference between the pressurization and depressurization test?

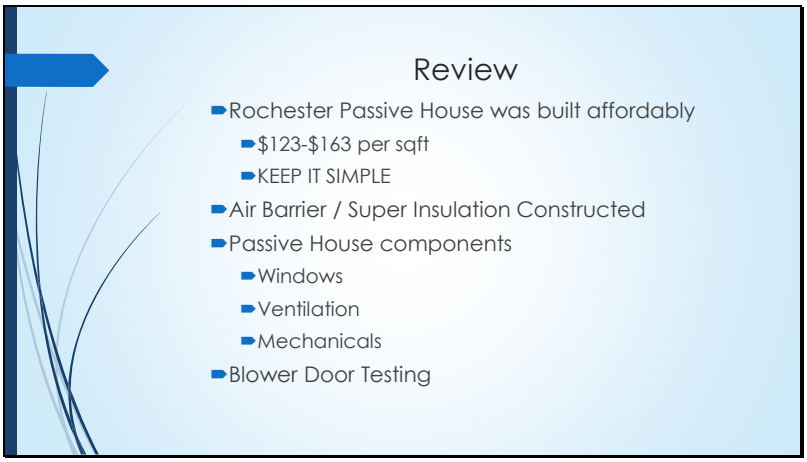
- When the house is pressurized the force on window gaskets are different.
- Seals between the assemblies were different clean frame inside, dirty outside

Slide 103



The use of Air Admittance Valves was used in many of the plumbing drains – to minimize plumbing penetrations. They work on opening when a sufficient pressure difference occurs allowing the water to fall and be followed by air. The pressurization test creates a similar situation, but the values didn't open enough to make a difference.

Slide 104



Rochester Passive House was built affordably
- $123-$163 per sqft
- KEEP IT SIMPLE
- Air Barrier / Super Insulation Constructed
- Passive House components
  - Windows
  - Ventilation
  - Mechanicals
- Blower Door Testing

Slide 105

Questions?

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