

LIVING WITH PASSIVE HOUSE

CASE STUDIES OF THE HUMAN EXPERIENCE

Richard Pedranti, AIA

RPA

Richard Pedranti Architect

September 30, 2017



PASSIVE HOUSE
ALLIANCE
UNITED STATES

LIVING WITH PASSIVE HOUSE

CASE STUDIES OF THE HUMAN EXPERIENCE

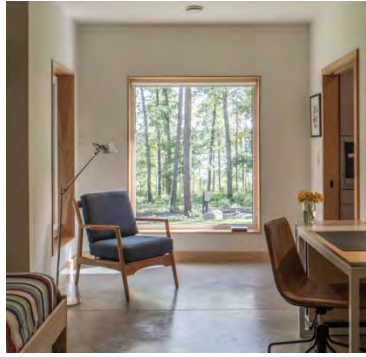
Presentation Outline

THEORY

1. RPA 5 Passive House Principles
2. RPA 5 human Passive House principles

PRACTICE

3. Case studies from our early Passive House work

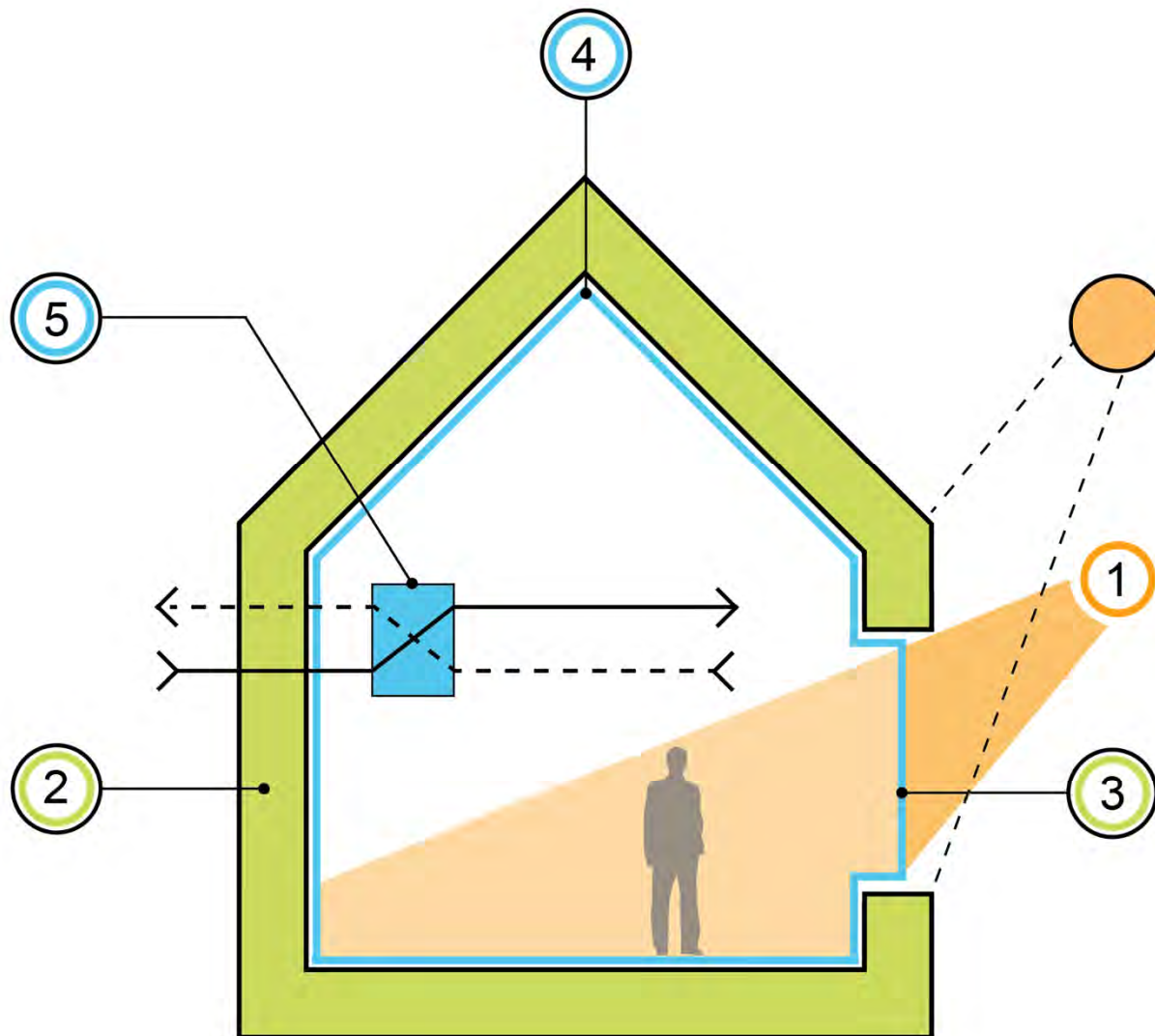


LIVING WITH PASSIVE HOUSE

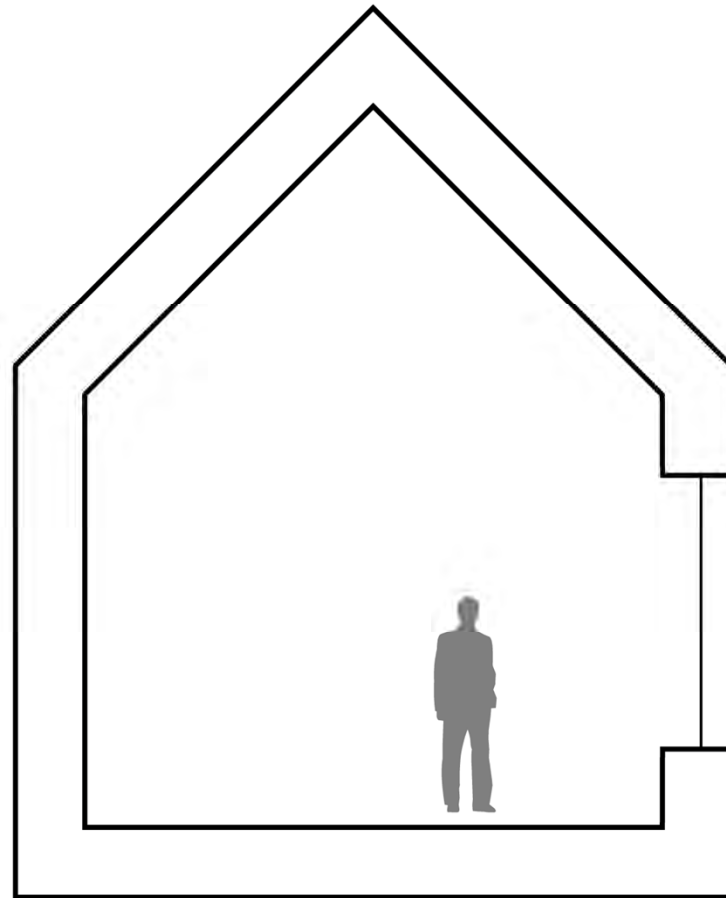
CASE STUDIES OF THE HUMAN EXPERIENCE



5 Passive House principles

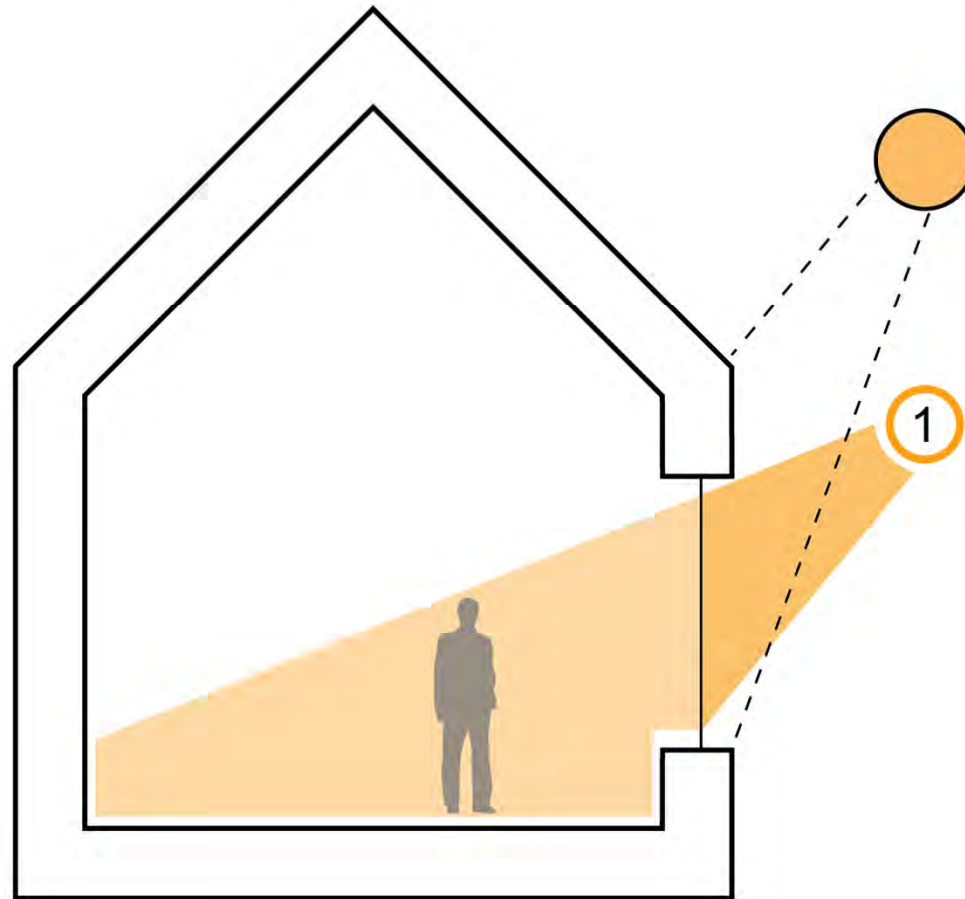


5 Passive House principles



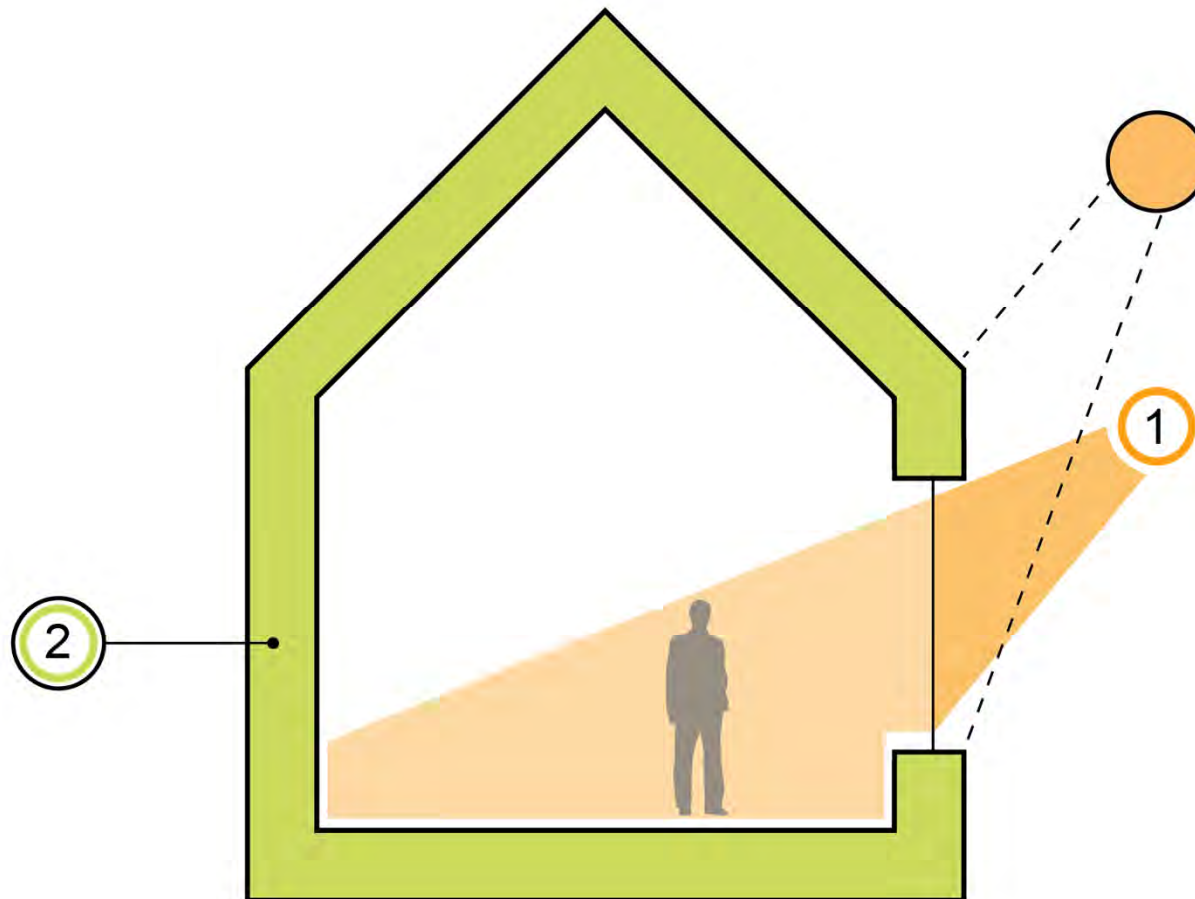
5 Passive House principles

1. SOLAR ORIENTATION



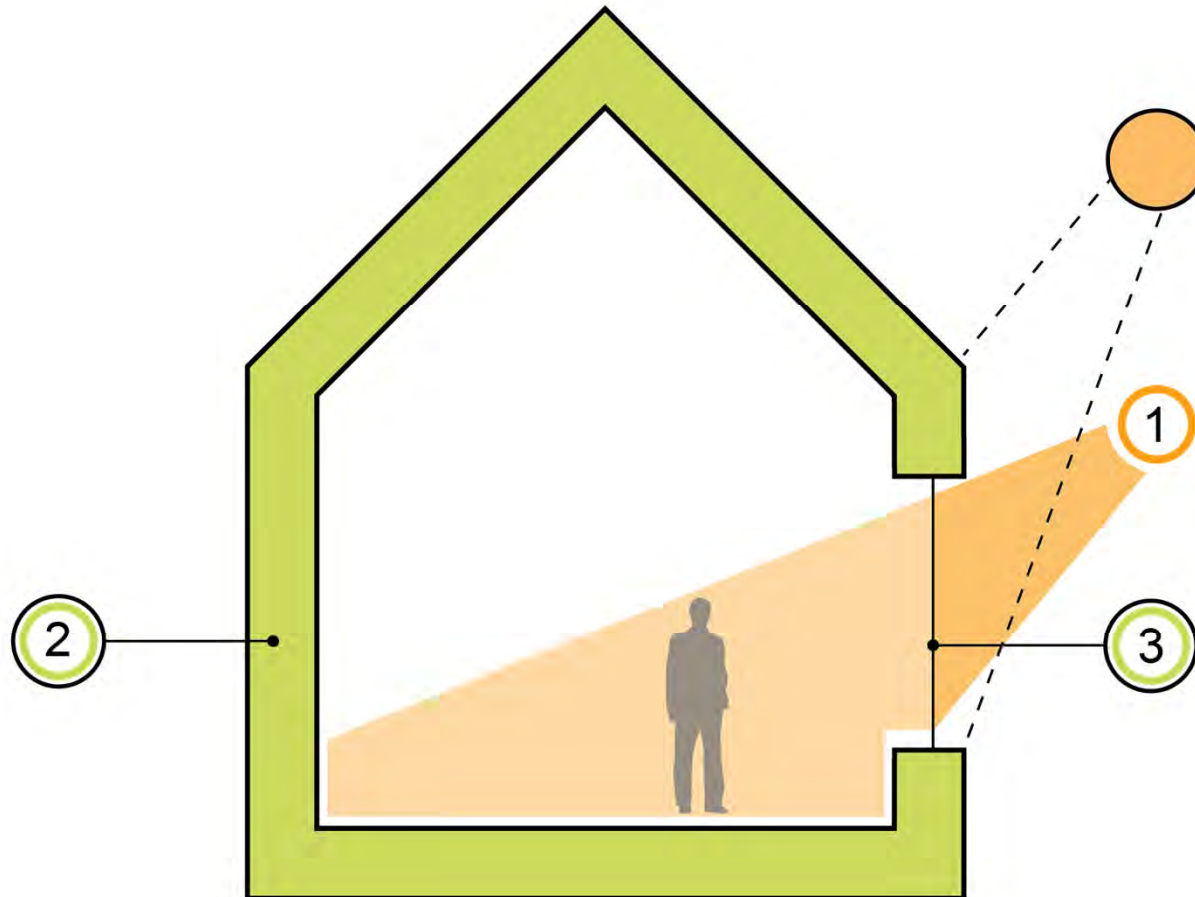
5 Passive House principles

1. SOLAR ORIENTATION
2. HIGH INSULATION



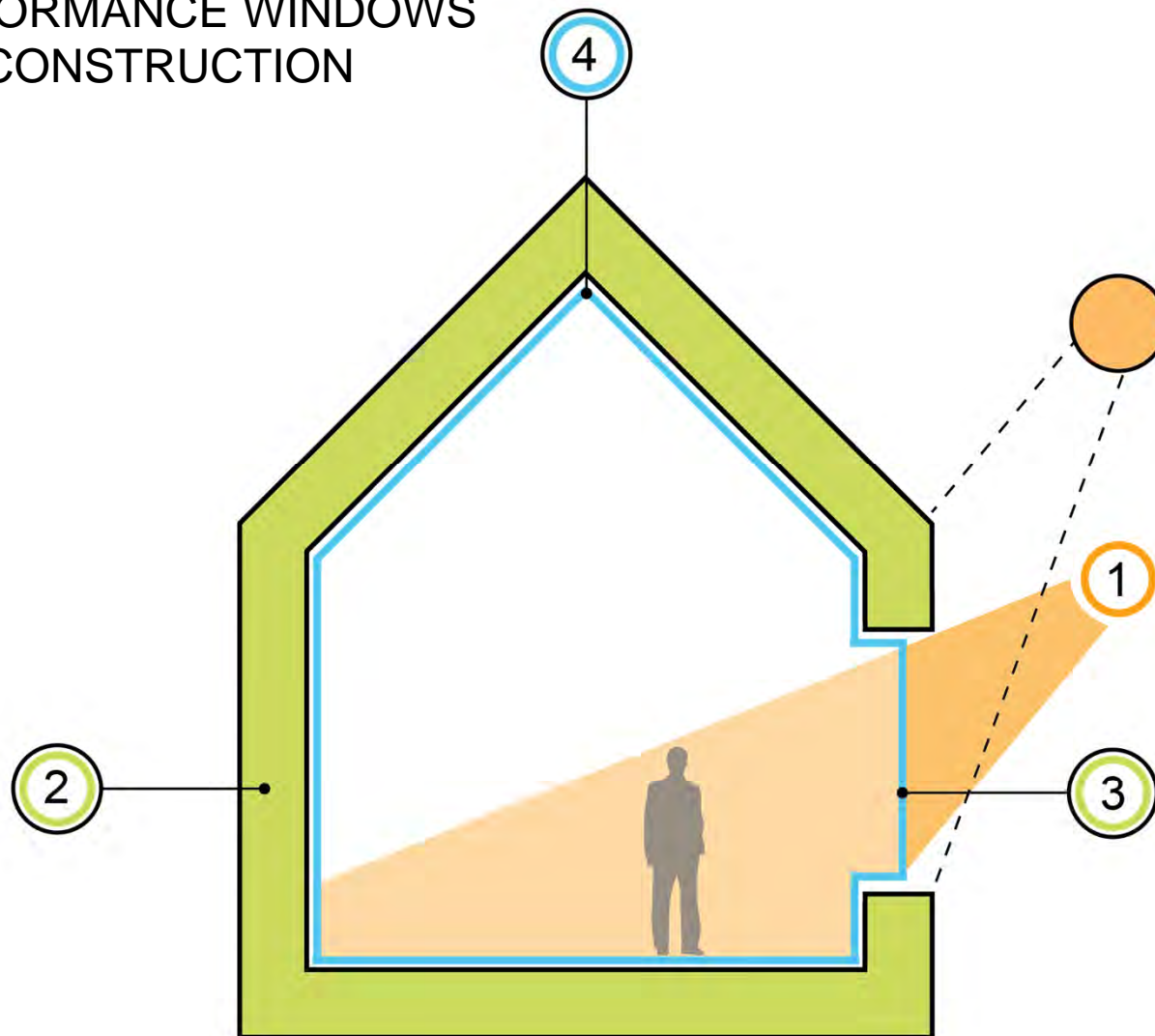
5 Passive House principles

1. SOLAR ORIENTATION
2. HIGH INSULATION
3. HIGH PERFORMANCE WINDOWS



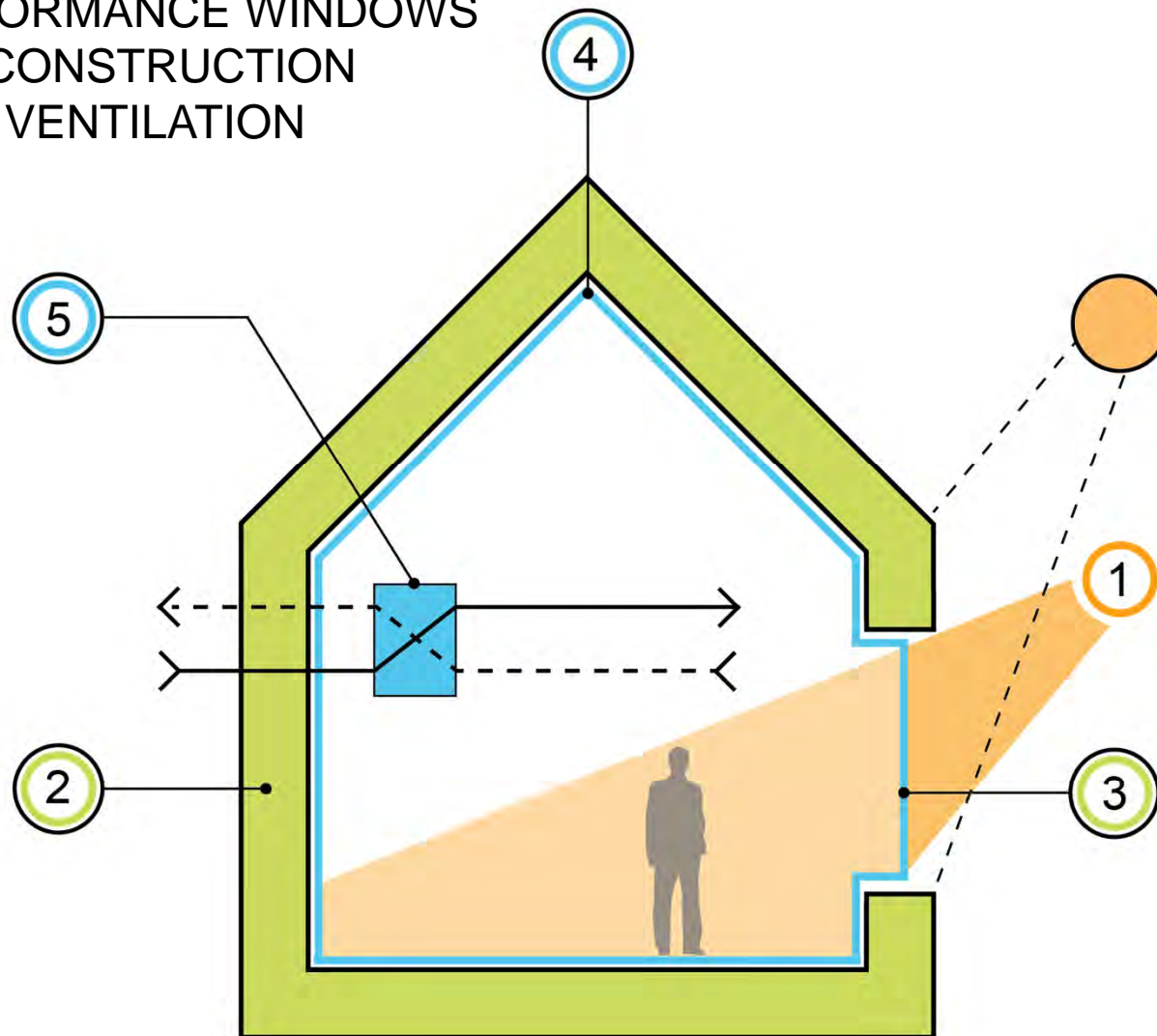
5 Passive House principles

1. SOLAR ORIENTATION
2. HIGH INSULATION
3. HIGH PERFORMANCE WINDOWS
4. AIR TIGHT CONSTRUCTION



5 Passive House principles

1. SOLAR ORIENTATION
2. HIGH INSULATION
3. HIGH PERFORMANCE WINDOWS
4. AIR TIGHT CONSTRUCTION
5. BALANCED VENTILATION





WINTER COMFORT SURVEY

RESULTS

50%



Report they struggle to feel warm and comfortable in during the winter months.

70%



Report that some or all walls in their homes are cold to touch.

43%



Report that rooms are avoided or unused because they are uncomfortably cold.

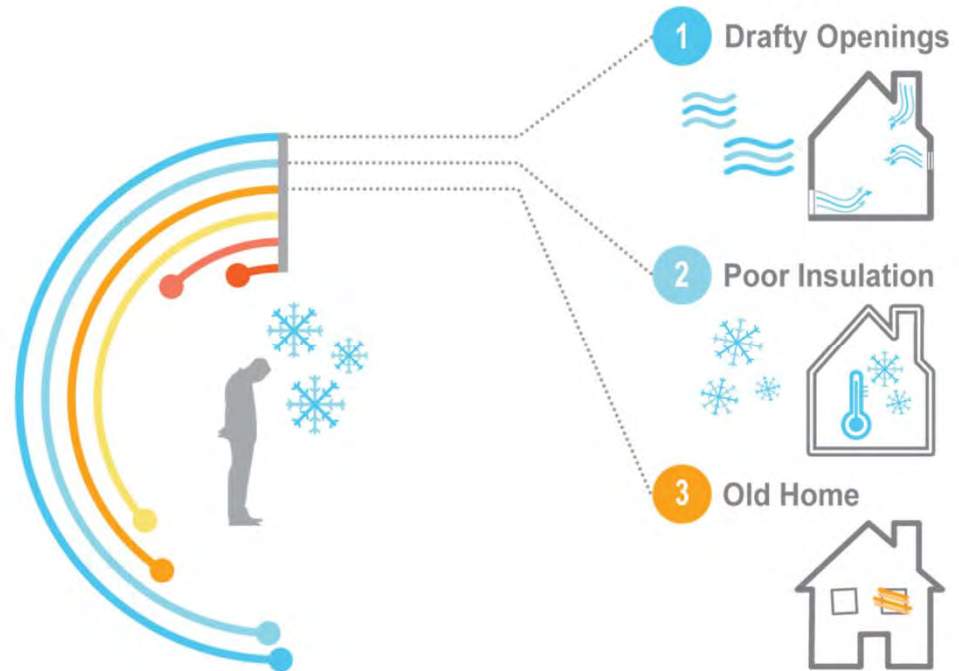


WINTER COMFORT SURVEY

WHY ARE WE UNCOMFORTABLE?

What factors are responsible when homes feel uncomfortable in the winter months?

	Drafty Openings	51%
	Poor Insulation	50%
	Old Home	42%
	Heating Cost	37%
	Old Heating System	13%
	Need System Maintenance	7%








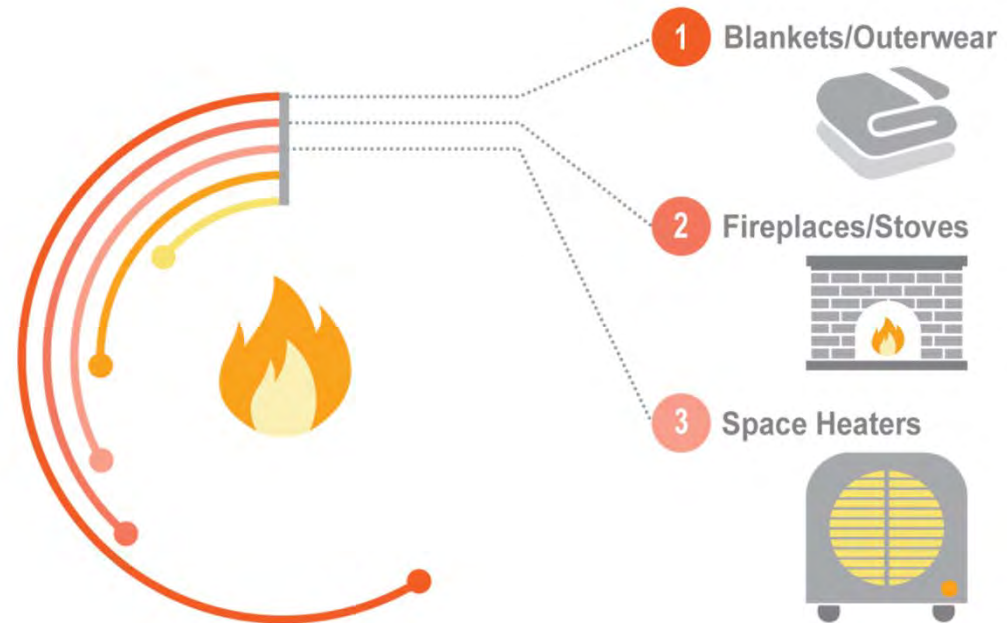


WINTER COMFORT SURVEY

HOW DO WE STAY WARM?

What steps are taken to stay comfortable in homes other than turning up the thermostat?

 Blankets/Outerwear	58%
 Fireplace/Stove	39%
 Space Heaters	35%
 Stay in warm rooms	27%
 Heated Floors/Other	13%

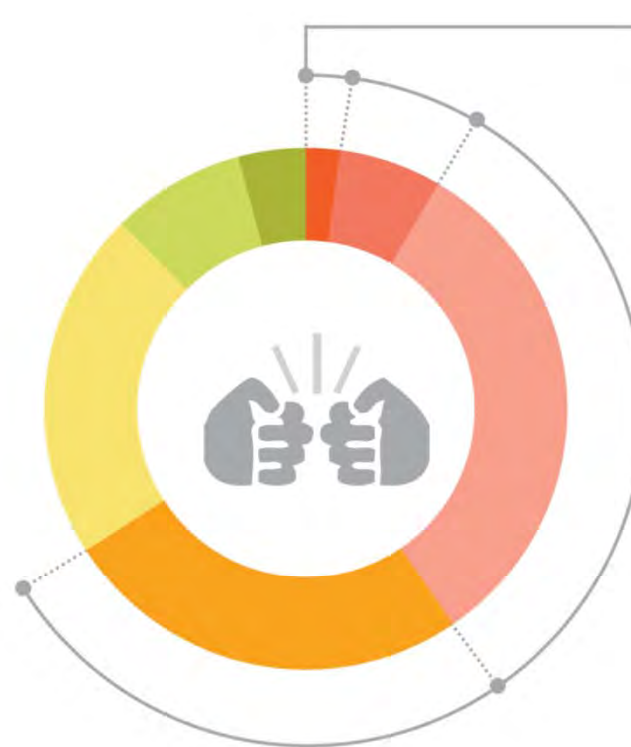




WINTER COMFORT SURVEY

FAMILIAL STRIFE

How regularly does balancing heating costs with keeping home warm during cold months cause disagreements with a spouse, partner, roommate(s) or children living in home?



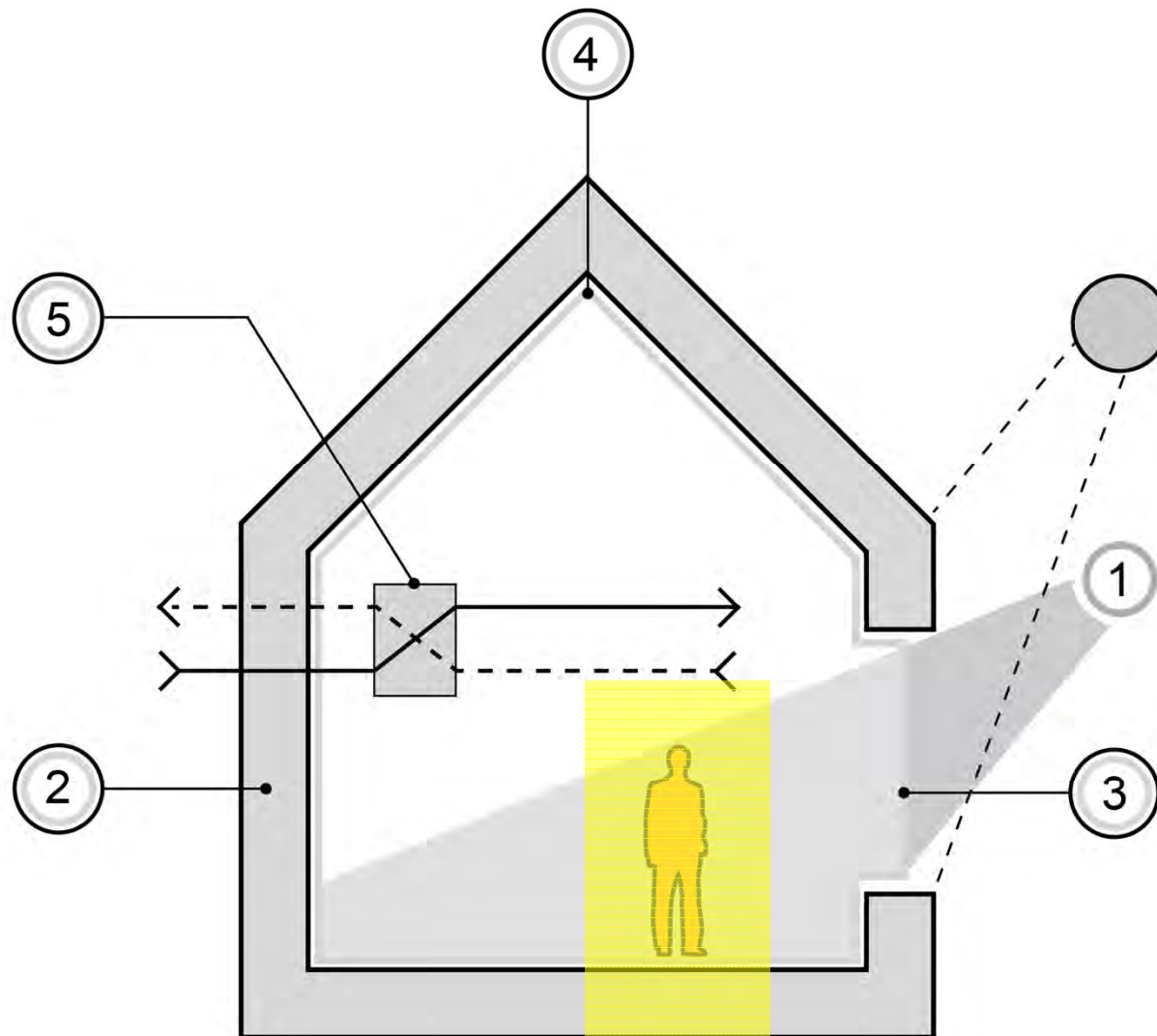
67%

Of homeowners say that deciding how to keep their home comfortable during the winter have caused disagreements between family or roommates.

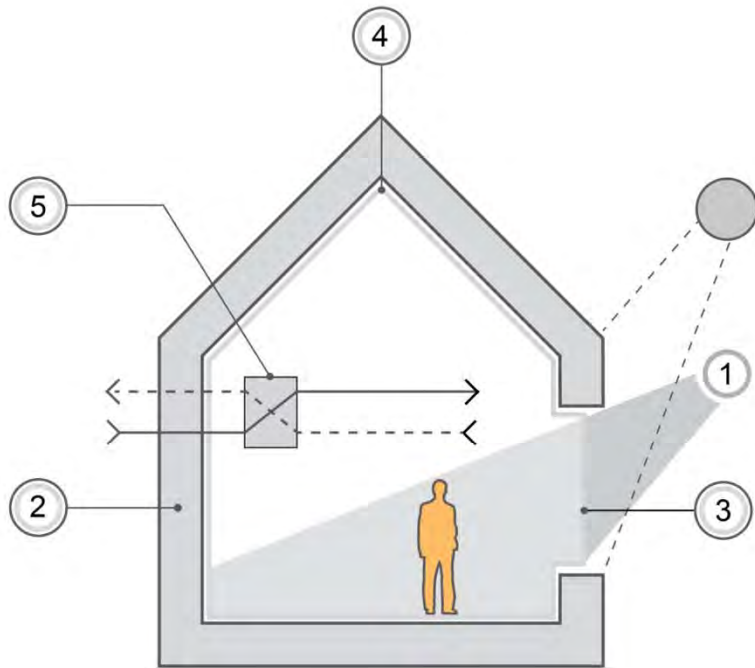
This is not just causing physical discomfort but emotional discomfort as well.

202 people living in detached homes, townhouses and row homes in areas that experience a winter season completed the survey.

5 Passive House principles

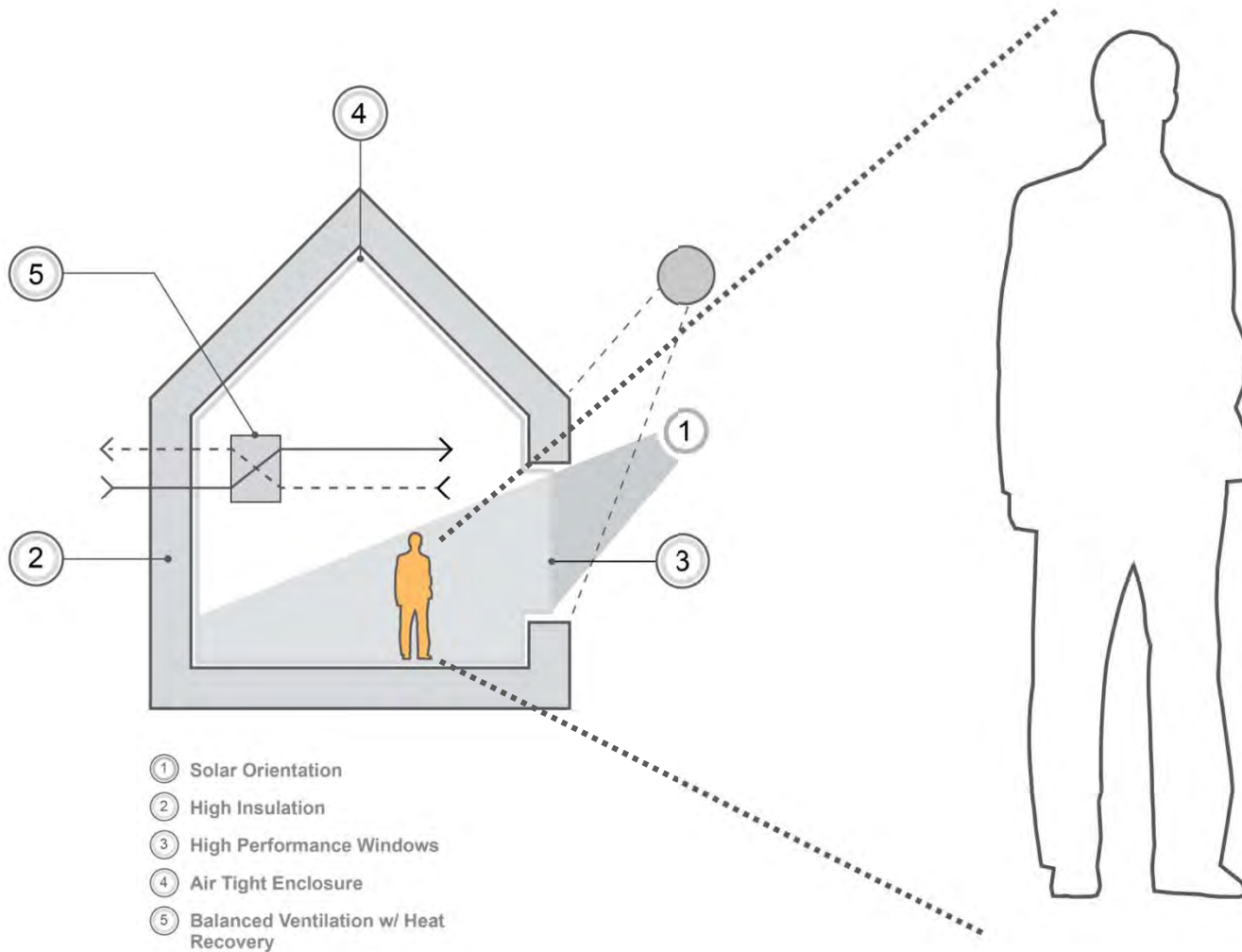


5 Passive House principles

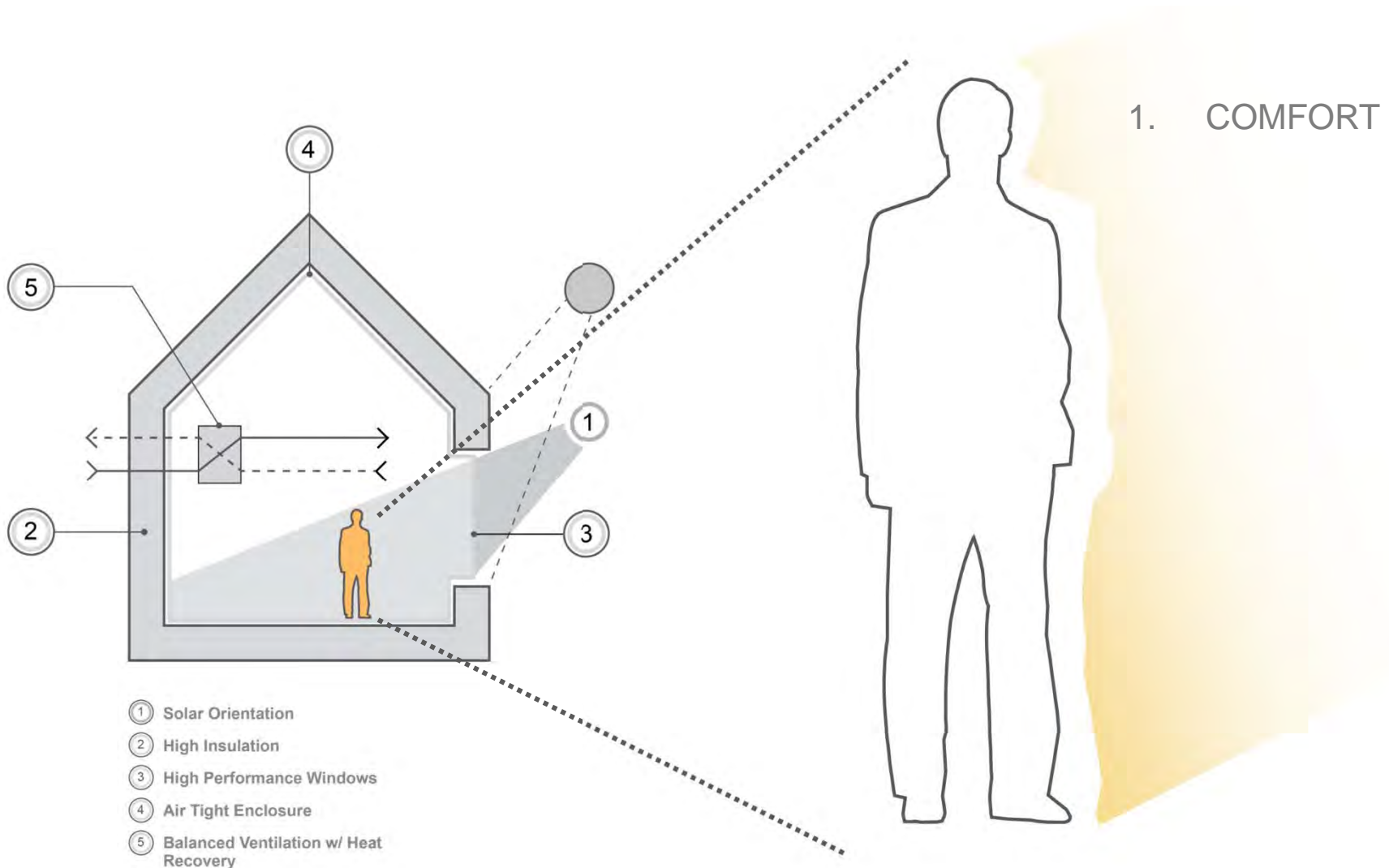


- ① Solar Orientation
- ② High Insulation
- ③ High Performance Windows
- ④ Air Tight Enclosure
- ⑤ Balanced Ventilation w/ Heat Recovery

5 Human Passive House principles



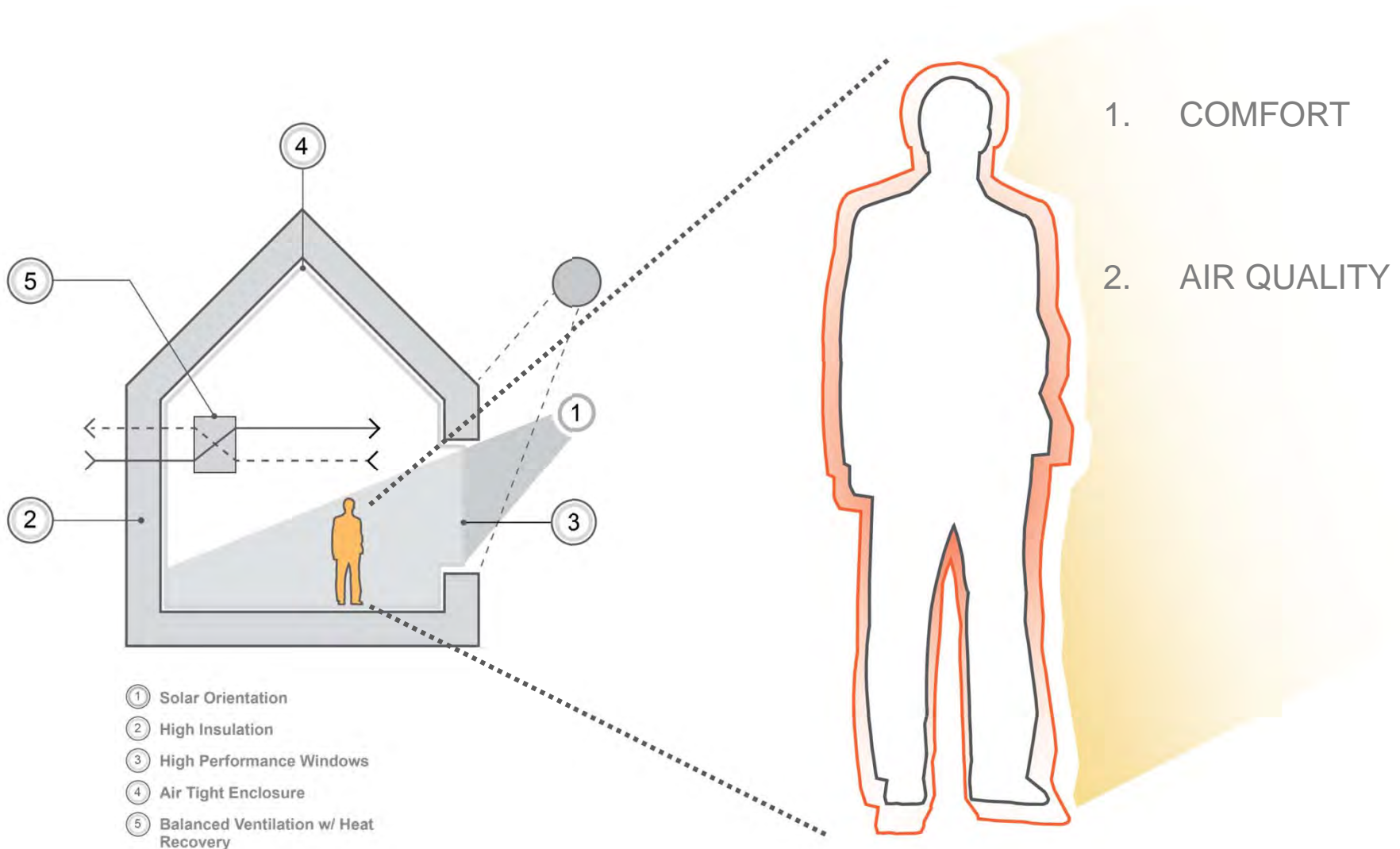
5 Human Passive House principles



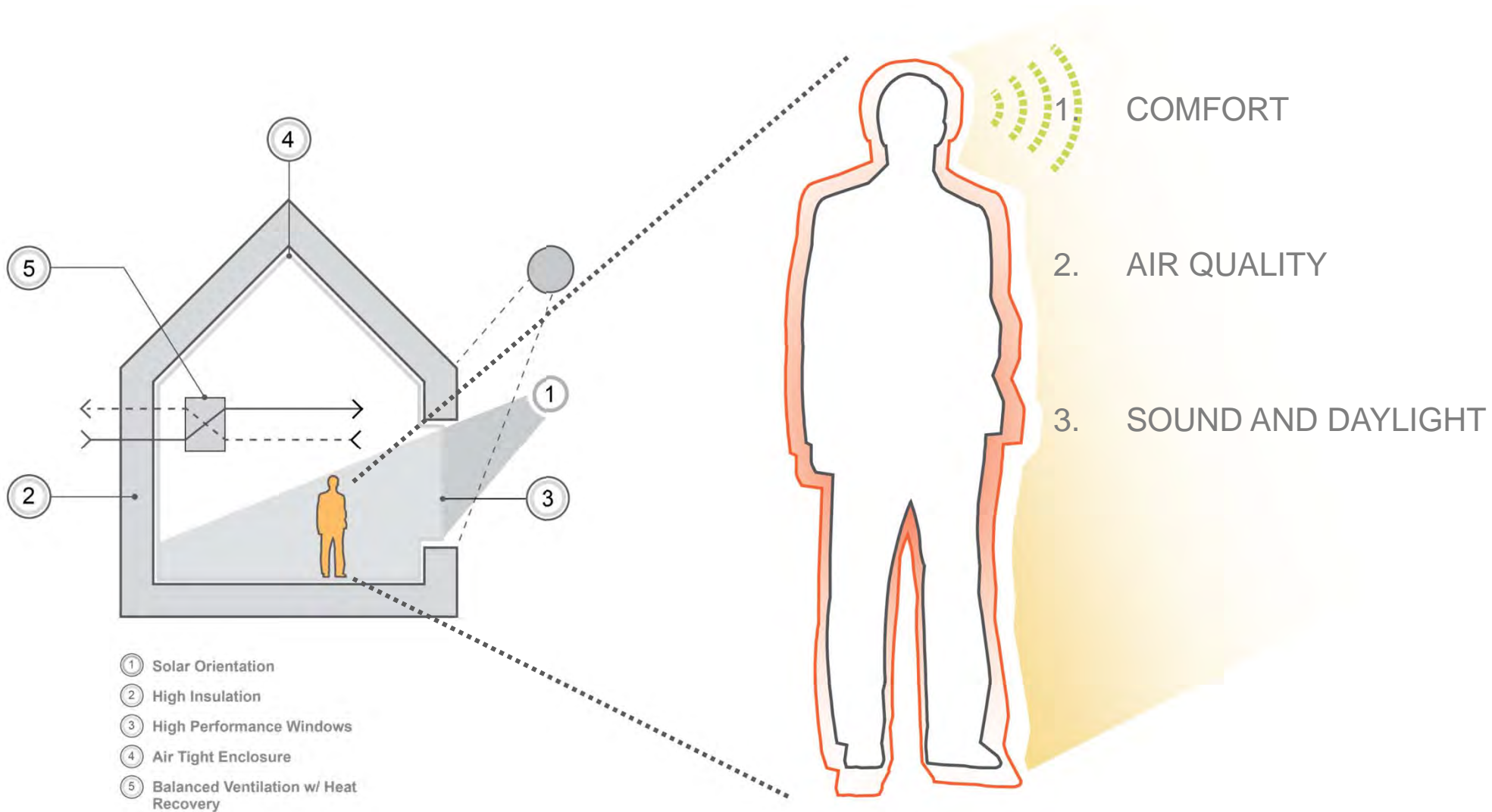
Thermal comfort is the condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation.

ASHRAE Standard 55 (2013). "Thermal Environmental Conditions for Human"

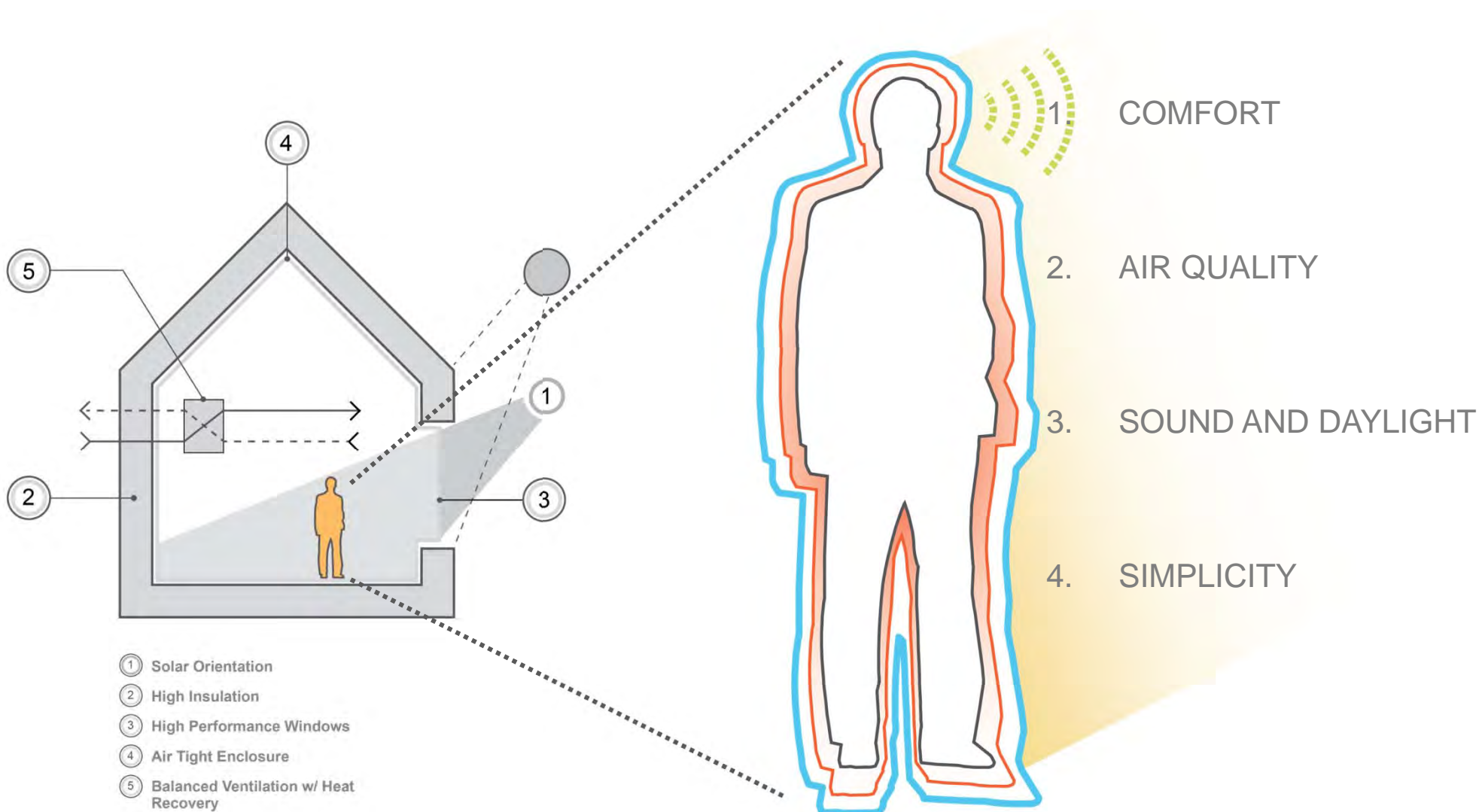
5 Human Passive House principles



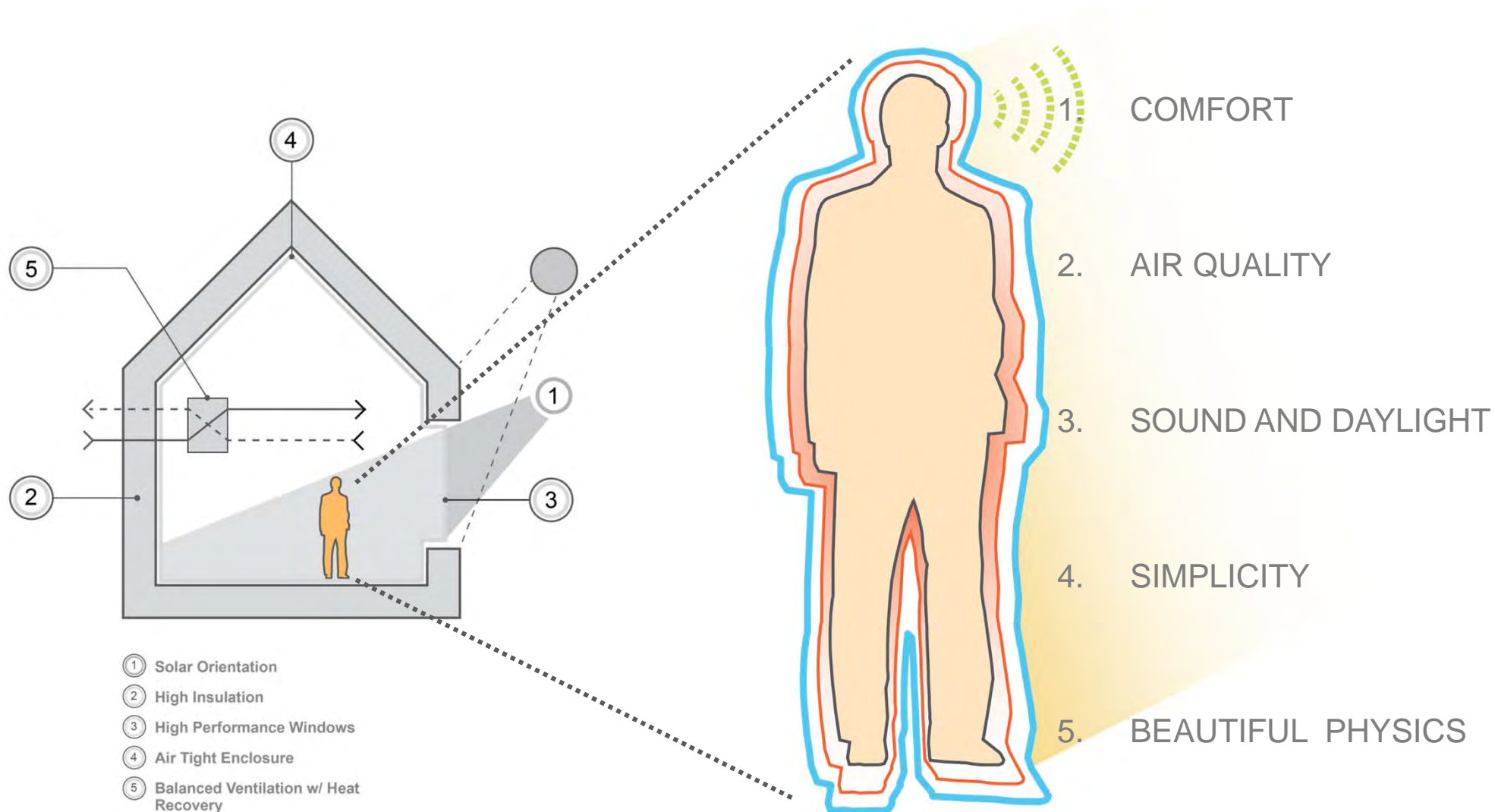
5 Human Passive House principles



5 Human Passive House principles



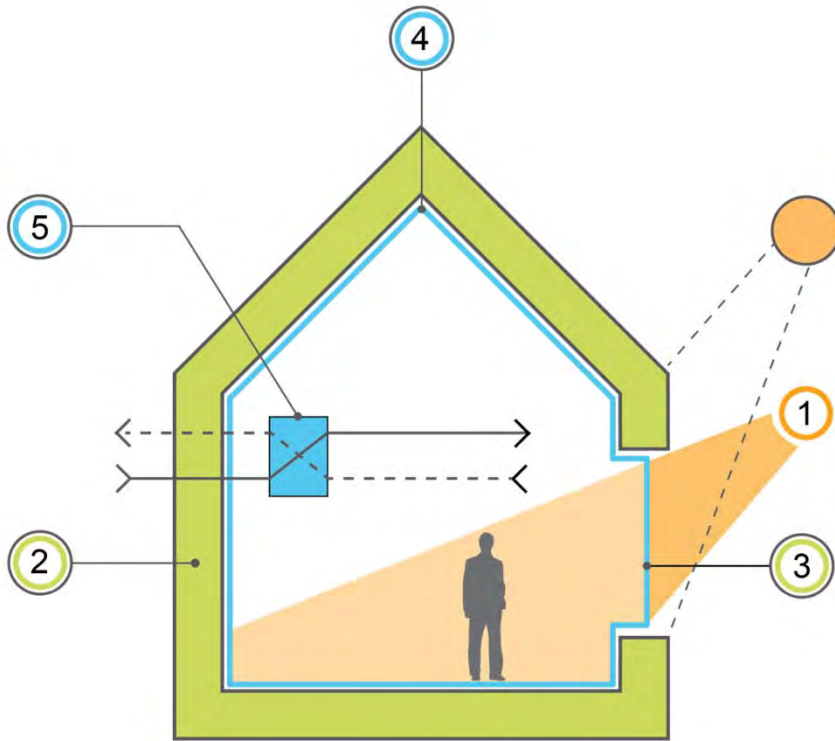
5 Human Passive House principles



“Increasing the insulation, window, and airtightness values to these levels is not only quite expensive, but very architecturally constraining”

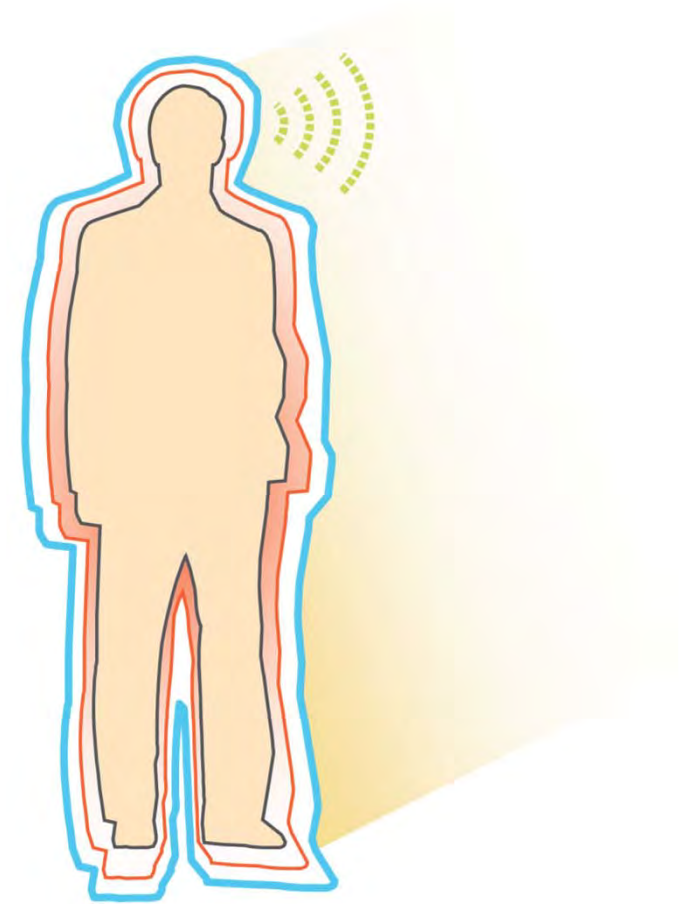
“The Passive House (Passivhaus) Standard – A comparison to other cold climate low energy housing”, John Straub 2010

Quantitative



1. SOLAR ORIENTATION
2. HIGH INSULATION
3. HIGH PERFORMANCE WINDOWS
4. AIR TIGHT CONSTRUCTION
5. BALANCED VENTILATION

Experience

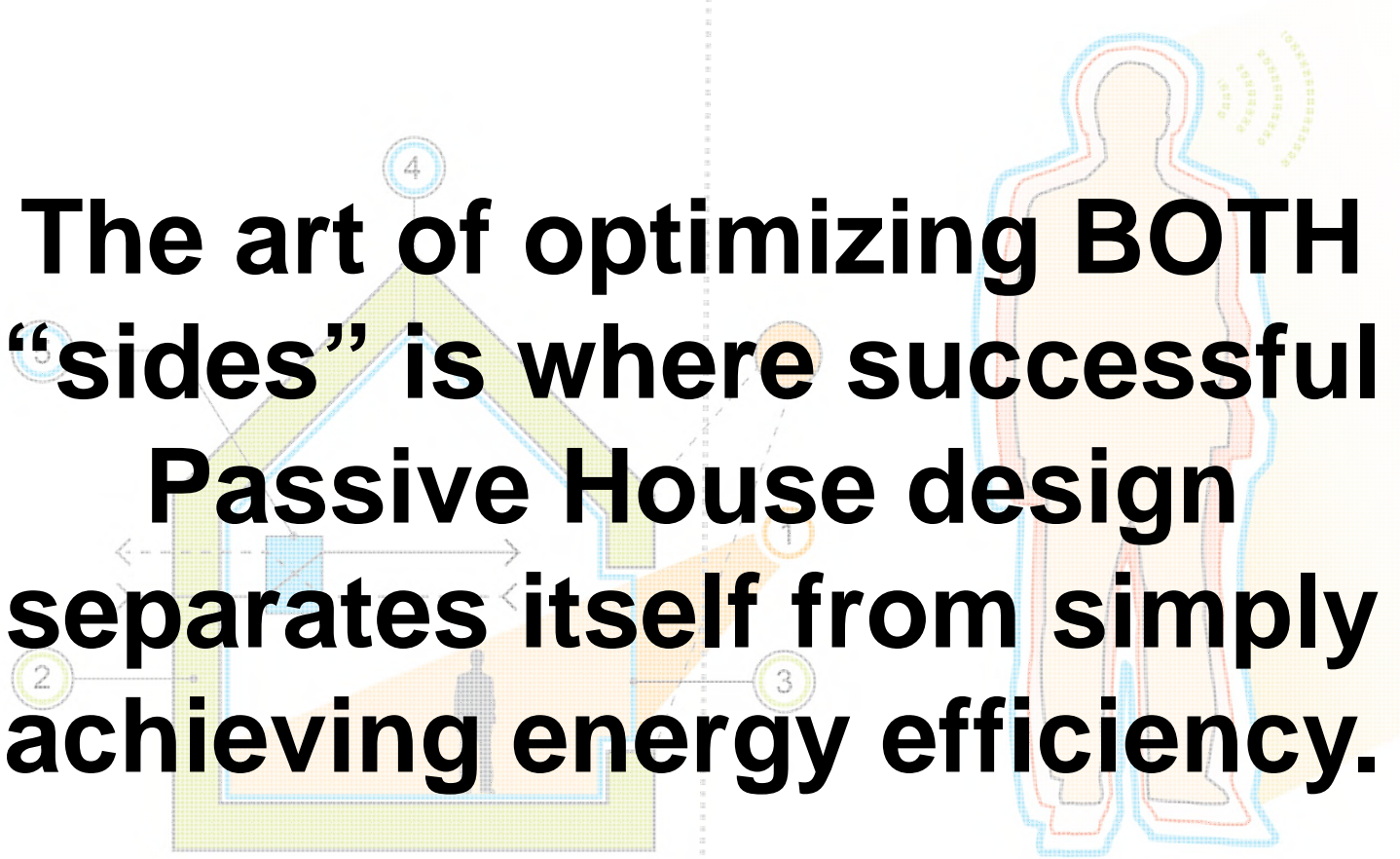


1. COMFORT
2. AIR QUALITY
3. SOUND AND DAYLIGHT
4. SIMPLICITY
5. BEAUTIFUL PHYSICS

Quantitative

Experience

The art of optimizing BOTH “sides” is where successful Passive House design separates itself from simply achieving energy efficiency.



1. SOLAR ORIENTATION
2. HIGH INSULATION
3. HIGH PERFORMANCE WINDOWS
4. AIR TIGHT CONSTRUCTION
5. BALANCED VENTILATION

1. COMFORT
2. AIR QUALITY
3. SOUND AND DAYLIGHT
4. SIMPLICITY
5. BEAUTY

CASE STUDIES

SCRANTON PASSIVE HOUSE



SCRANTON
PASSIVE HOUSE

KEFFER PASSIVE HOUSE

 KEFFER
PASSIVE HOUSE



SOEDER PASSIVE HOUSE

SOEDER
PASSIVE HOUSE

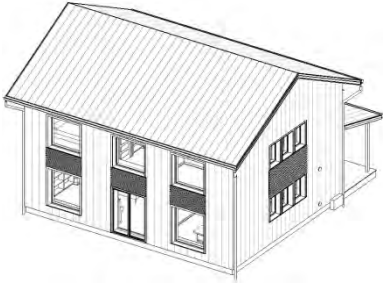


Scranton Passive House

Keffer Passive House

Soeder Passive House

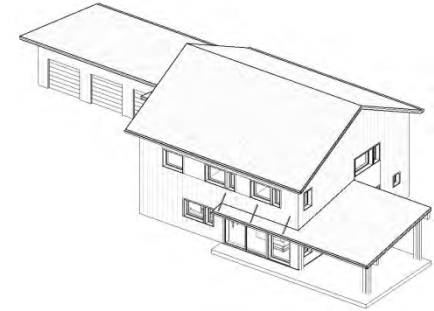
3D



3D



3D



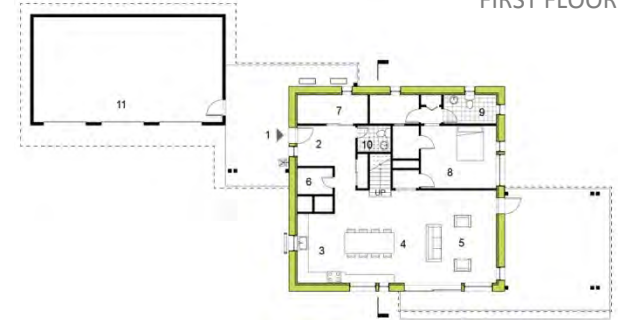
FIRST FLOOR



FIRST FLOOR



FIRST FLOOR



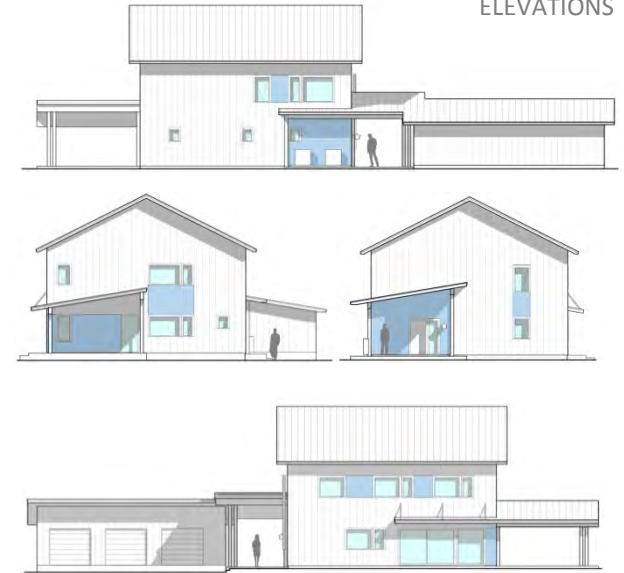
ELEVATIONS



ELEVATIONS



ELEVATIONS



Scranton Passive House



Keffer Passive House



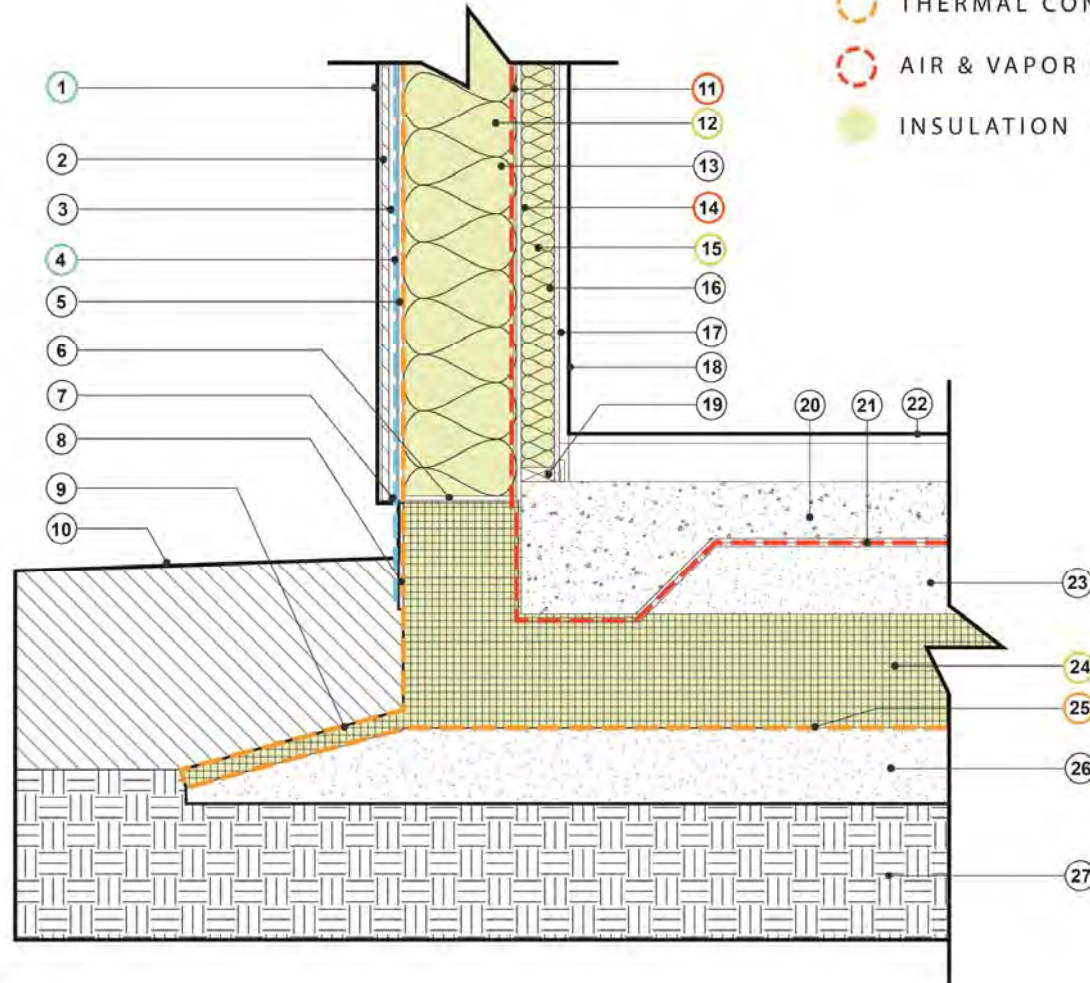
Soeder Passive House



FOUNDATION ASSEMBLY

WALL-SLAB DETAIL

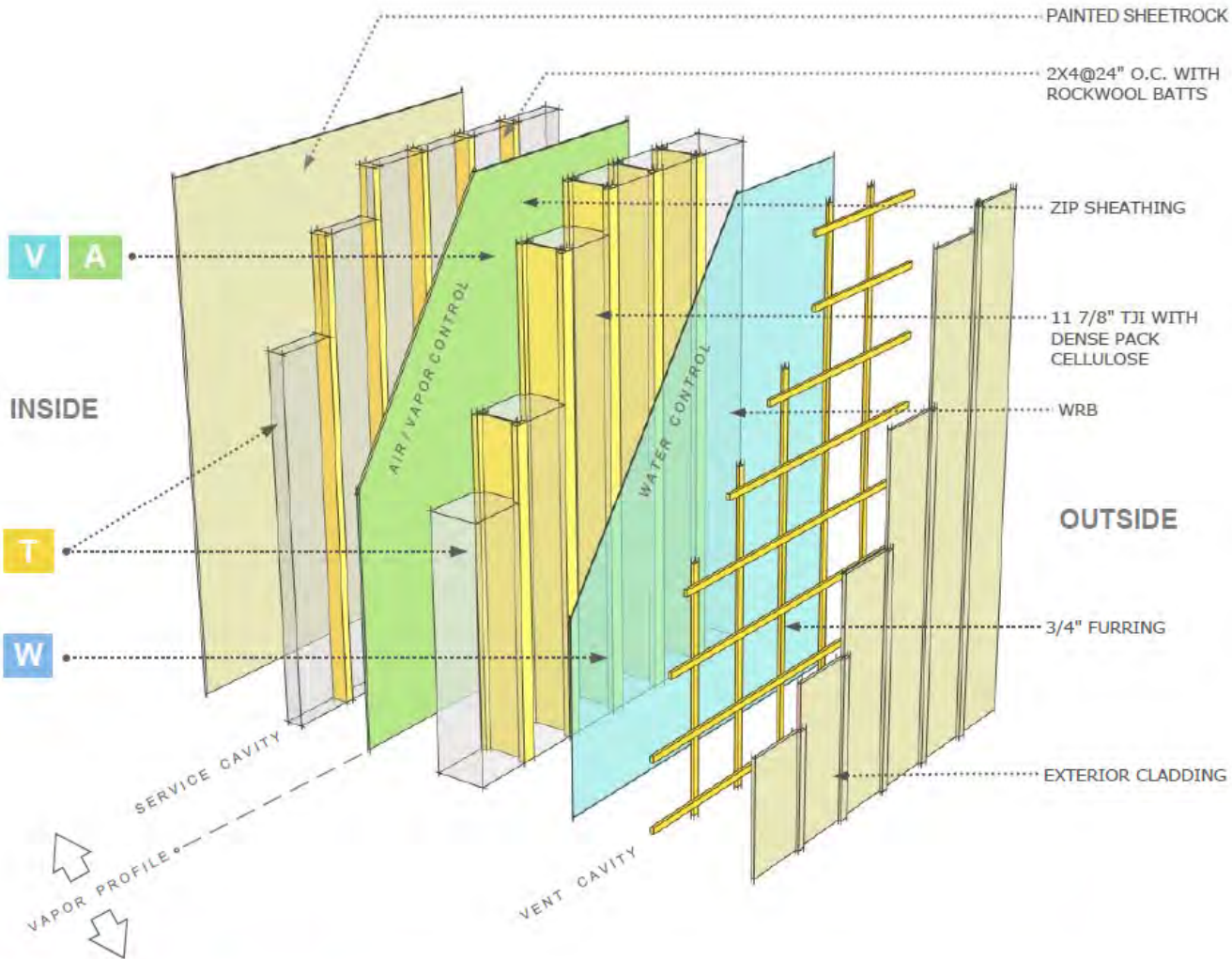
- 1 WATER CONTROL LAYER
- 2 PAINTED WOOD CLADDING
- 3 3/4" FURRING AND AIR SPACE
- 4 SIGA MAJVEST WRB
- 5 FIBERBOARD SHEATHING
- 6 1 1/4" PSL
- 7 SCREENED CLADDING VENT
- 8 PARGED FIBER-CEMENT
- 9 2" EPS FROST WING
- 10 GRADE
- 11 AIR & VAPOR CONTROL LAYER
- 12 11 7/8" DENSE PACK CELLULOSE INSULATION
- 13 11 7/8" TJI
- 14 OSB | SEAMS TAPED WITH SIGA WIGLUV
- 15 3 1/2" MINERAL WOOL INSULATION
- 16 STRUCTURAL 2X4" STUD WALL
- 17 5/8" GYPSUMBOARD
- 18 INTERIOR FINISH
- 19 2X4" PLATE
- 20 6" POURED CONCRETE SLAB
- 21 10 MLL POLY
- 22 FLOORING
- 23 8" PERLITE
- 24 12" EPS INSULATION
- 25 THERMAL CONTROL LAYER
- 26 8" COMPACTED #2B STONE
- 27 UNDISTURBED SOIL



- WATER CONTROL LAYER
- THERMAL CONTROL LAYER
- AIR & VAPOR CONTROL LAYER
- INSULATION

R=78

WALL ASSEMBLY



RPA

WALL PH-1

Super-insulated Passive House wall

CLIMATE ZONES 5 AND 6

- A proven Passive House wall assembly
- Has a high R-value
- Uses conventional building technology
- Has an excellent vapor profile
- All 4 control layers are continuous
- Cellulose is hygroscopic
- Cellulose is inexpensive
- Cellulose has low embodied energy
- The primary air seal is rigid and protected
- Has a service cavity
- Is thermal bridge free
- Vent space at cladding allows for drying

CONTROL LAYERS

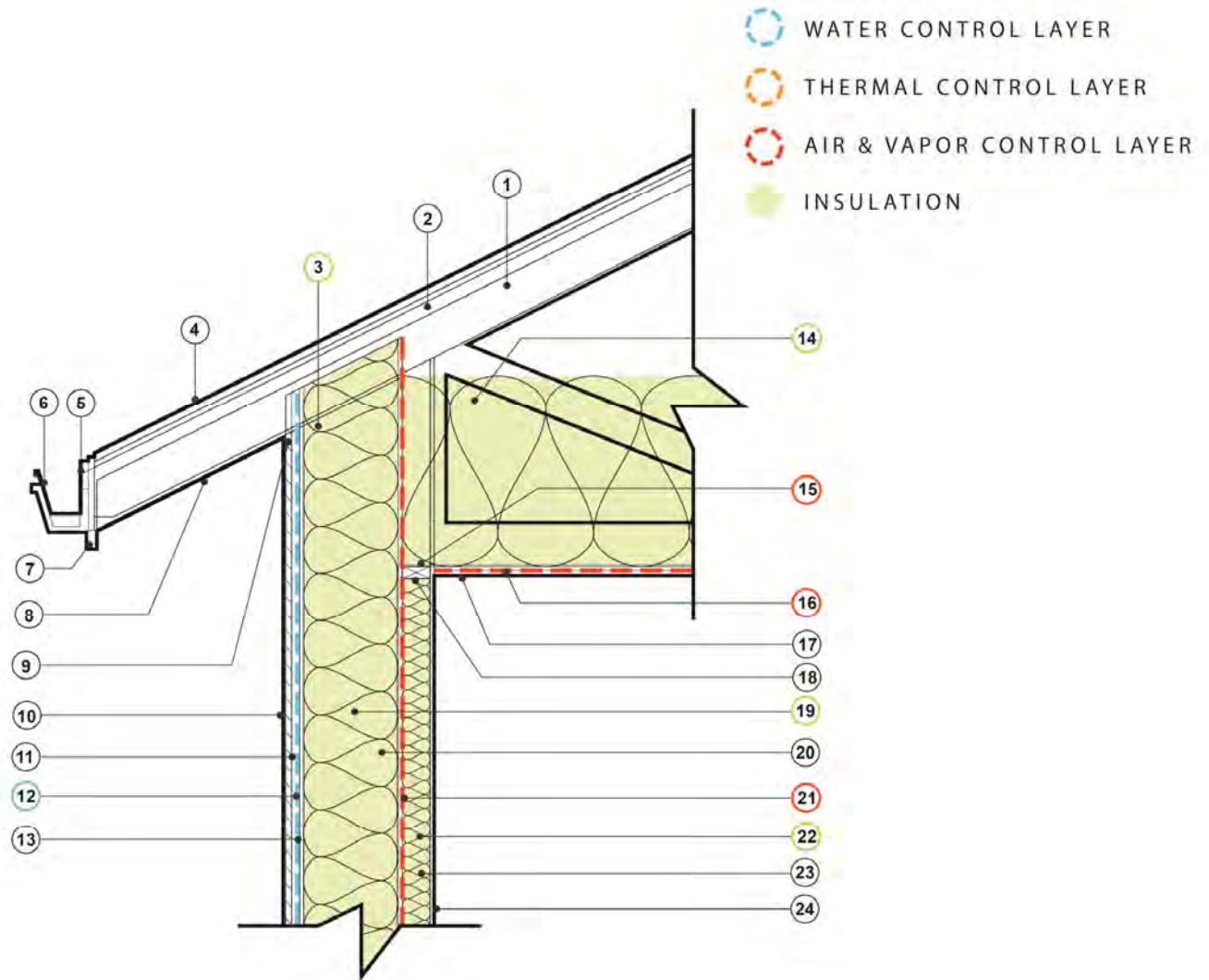
T	THERMAL	CELLULOSE / ROCKWOOL
W	WATER	SOLITEX MENTO
A	AIR	HUBER ZIP SHEATHING
V	VAPOR	HUBER ZIP SHEATHING

R=61

ROOF ASSEMBLY

WALL-ROOF DETAIL

- 1 30" RAISED HEEL TRUSS
- 2 5/8" ROOF SHEATHING
- 3 INSULATION BAFFLE
- 4 METAL ROOF
- 5 ALUMINUM DRIP EDGE
- 6 CONTINUOUS ALUMINUM GUTTER
- 7 PAINTED TRIM
- 8 VENTED SOFFIT
- 9 SCREEN CLADDING VENT
- 10 PAINTED WOOD CLADDING
- 11 3/4" FURRING AND CLADDING VENT SPACE
- 12 SIGA MAJVEST WRB
- 13 FIBERBOARD SHEATHING
- 14 24" LOOSE FILL CELLULOSE INSULATION
- 15 12" OSB STRIP ON TOP PLATE
- 16 OSB | SEAMS TAPED WITH SIGA WIGLUV
- 17 5/8" GYPSUMBOARD
- 18 2x4" TOP PLATE
- 19 11 7/8" DENSE PACK CELLULOSE INSULATION
- 20 11 7/8" TJI
- 21 OSB | SEAMS TAPED WITH SIGA WIGLUV
- 22 3 1/2" MINERAL WOOL
- 23 2X4" STRUCTURAL WALL @ 24" O.C.
- 24 5/8" GYPSUMBOARD

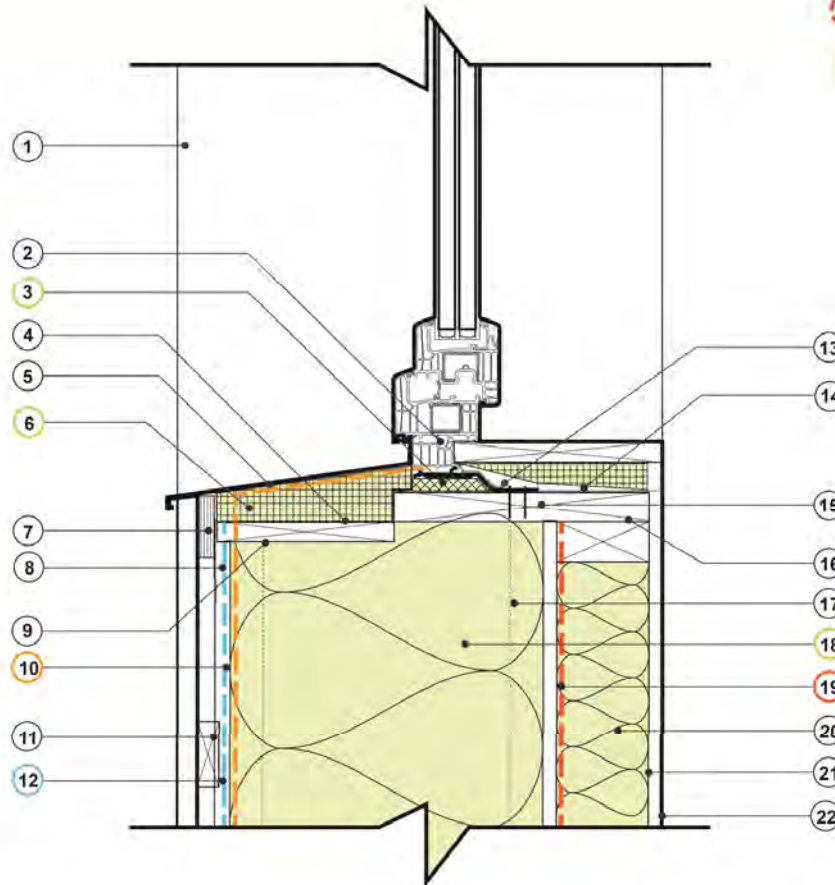






R=96

WINDOWS

WINDOW SILL DETAIL

- 1 WINDOW JAMB BEYOND
- 2 UNDER SILL PROFILE BY INTUS
- 3 SPRAY FOAM OR FOAM TAPE
- 4 3M 8067 TAPE
- 5 METAL WINDOW SILL
- 6 EPS INSULATION
- 7 COR O VENT
- 8 SIGA WIGLUV | SIGA MAJVEST WRB
- 9 3/4" WINDOW JAMB EXTENSION
- 10 THERMAL CONTROL LAYER
- 11 3/4" FURRING AND AIR SPACE
- 12 SIGA MAJVEST WRB
- 13 WINDOW INSTALLATION CLIP
- 14 VYCOR
- 15 1 1/4" #12 WOOD SCREWS
- 16 1 1/4" TIMBERSTRAND
- 17 1 1/8" TJI VERTICAL
- 18 DENSE PACK CELLULOSE
- 19 OSB | SEAMS TAPED WITH SIGA WIGLUV
- 20 MINERAL WOOL INSULATION IN SERVICE CAVITY
- 21 3 1/2" STRUCTURAL STUD WALL @ 24" O.C.
- 22 PAINTED GYPSUM BOARD (INTERIOR FINISH)



-  WATER CONTROL LAYER
-  THERMAL CONTROL LAYER
-  AIR & VAPOR CONTROL LAYER
-  INSULATION

R=6.7

MECHANICAL SYSTEMS

Scranton Passive House

Keffer Passive House

Soeder Passive House



EV200 RENEWAIRE



ZEHNDER CA 350



ZEHNDER CA 350



MITSUBISHI MUZ 9000



2 MITSUBISHI MUZ 12000



2 MITSUBISHI MUZ 12000



GE GEOSPRING HWHP



NYLE GEYSER HWHP &
MARATHON ELECTRIC WH



GE GEOSPRING HWHP

VENTILATION

HEATING / COOLING

HOT WATER

SCRANTON PASSIVE HOUSE

“Once we decided to build a house, the only sensible thing to do in the 21st century is to build a house that uses the least energy possible.”

Declan Mulhall, homeowner



DATA

Scranton Passive House

Projected Performance Information

PROJECT INFORMATION

LOCATION
 SIZE
 CLIMATE ZONE
 HERS
 CONSTRUCTION
 COST (EXTRA COST)
 MODELING TOOLS
 MONITORING
 PV TO NET ZERO

SCRANTON, PA
 2,153 SQFT.
 5/6 COLD
28
 COMPLETE 2015
 \$156/SQFT.
 PHPP / REMRATE
 RPA PHIOT
 5KW

RPA PH GEOMETRY

ENVELOPE AREA TO TFA
 SURFACE AREA TO VOLUME
 ENVELOPE AREA TO GLAZING
 SOUTH GLAZING
 ENCLOSURE R-VAULE

3
 32
 14%
 47%
 36.2

PASSIVE HOUSE METRICS

ANNUAL HEAT DEMAND
 HEAT LOAD
 PRIMARY ENERGY
 AIR TIGHTNESS
 TREATED FLOOR AREA

4.52 KBTU/(FT2YR)
 2.75 KBTU/(FT2YR)
 31.5 KBTU/(FT2YR)
 0.47ACH@50PA
 1,750 SQFT.

CONSTRUCTION SPECS

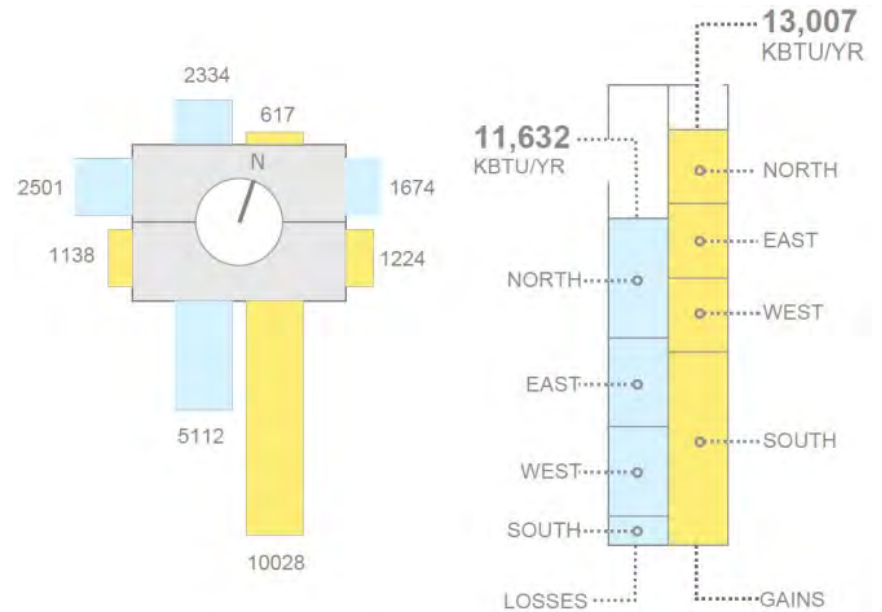
FLOOR
 WALLS
 ROOF
 WINDOWS

R=76 SLAB ON GRADE
 R=61 2X4 WALL PLUS TJI
 R=91 ENERGY TRUSS
 R=7 INTUS EFORTE

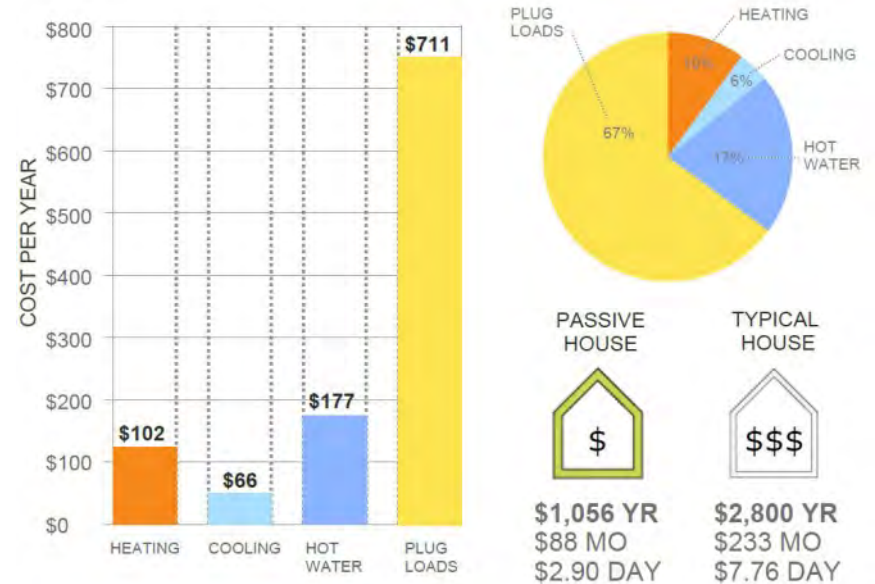
MECHANICAL SYSTEMS

VENTILATION
 HEATING AND COOLING
 DOMESTIC HOT WATER

RENEWAIRE ERV
 MITSUBISHI ASHP
 GE HWHP

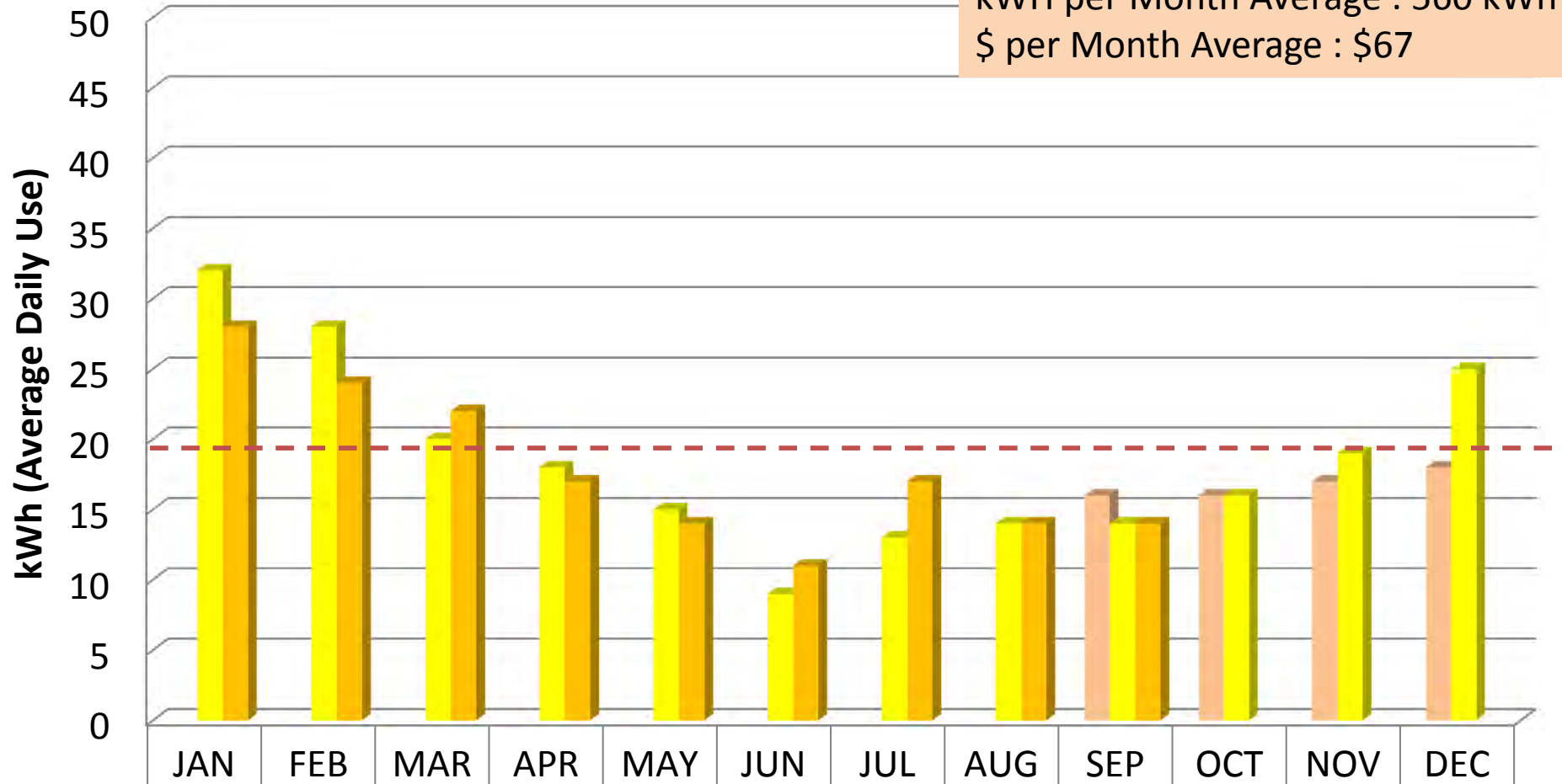


GLAZING SOLAR GAINS AND LOSSES BY ORIENTATION



OPERATING EXPENSE

kWh per Month Average : 560 kWh
 \$ per Month Average : \$67



--- Year Average

SCRANTON PASSIVE HOUSE

The #112 PHIUS certified Passive House in North America



Declan Mulhall
and
Christie Karpiak

SCRANTON PASSIVE HOUSE



**“It is
beautifully
designed,
warm/cool,
cheap to
run, silent,
and
comfy.”**

Declan Mulhall, Homeowner

SCRANTON PASSIVE HOUSE

“The thick front and side doors are finicky, and the sliding door is a total pain in the ass.”

Declan Mulhall, homeowner



SCRANTON PASSIVE HOUSE

The high energy use days are on weekends and the dryer is the number 1 culprit. **Awful energy use from the dryer.** We don't hang dry enough.

Christie Karpiak, homeowner



SCRANTON PASSIVE HOUSE



“I still don't like the air registers. Hotel-esque, loud and annoying but only noticeable at night.”

Christie Karpiak

SCRANTON PASSIVE HOUSE

“The water heater is great, in my opinion. Definitely plenty of hot water on the efficient setting and no real problems from the cold air.”

Christie Karpiak



SCRANTON PASSIVE HOUSE

“No cooking odors.”

Christie Karpiak



SCRANTON PASSIVE HOUSE



SCRANTON PASSIVE HOUSE

LESSONS LEARNED

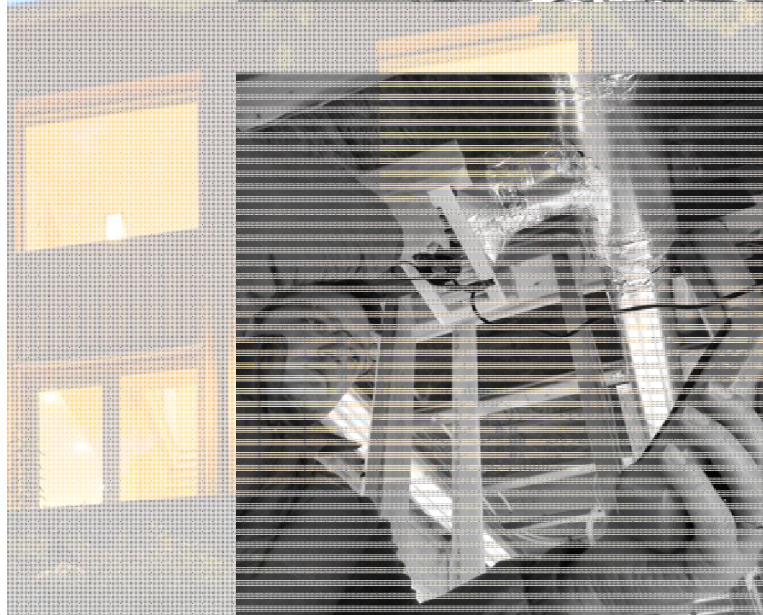
1. OSB is not a reliable air barrier.

See:

[“Is OSB Airtight”](#) by Martin Holladay on GBA website.

2. Installing the Renewaire HRV and ductwork was challenging.

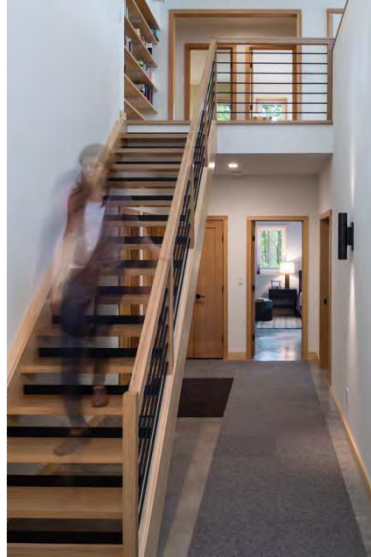
3. With carefully optimized design, it is possible to build an affordable Passive House in our region. **\$156/ sf**



KEFFER PASSIVE HOUSE

“It made sense to us to build a house that met the most advanced building and energy standards possible.”

Lynn Keffer, homeowner



DATA

Keffer Passive House

Projected Performance Information

PROJECT INFORMATION

LOCATION

SIZE

CLIMATE ZONE

HERS

CONSTRUCTION

COST

MODELING TOOLS

MONITORING

PV TO NET ZERO

HAWLEY, PA

2,900 SQFT.

5

32

2016

\$225 SQFT.

PHPP / REMRATE

PHIoT

7KW

RPA PH GEOMETRY

ENVELOPE AREA TO TFA

SURFACE AREA TO VOLUME

ENVELOPE AREA TO GLAZING

SOUTH GLAZING

ENCLOSURE R-VAULE

3.5

34

15%

67%

42.3

PASSIVE HOUSE METRICS

ANNUAL HEAT DEMAND

HEAT LOAD

PRIMARY ENERGY

AIR TIGHTNESS

TREATED FLOOR AREA

4.65 KBTU/(FT2YR)

2.93 KBTU/(FT2YR)

27.3 KBTU/(FT2YR)

0.29ACH@50PA

2,304 SQFT.

CONSTRUCTION SPECS

FLOOR

WALLS

ROOF

WINDOWS

R=76 SLAB ON GRADE

R=62 2X4 WALL PLUS TJI

R=100 ENERGY TRUSS

R=7 INTUS EFORTE

MECHANICAL SYSTEMS

VENTILATION

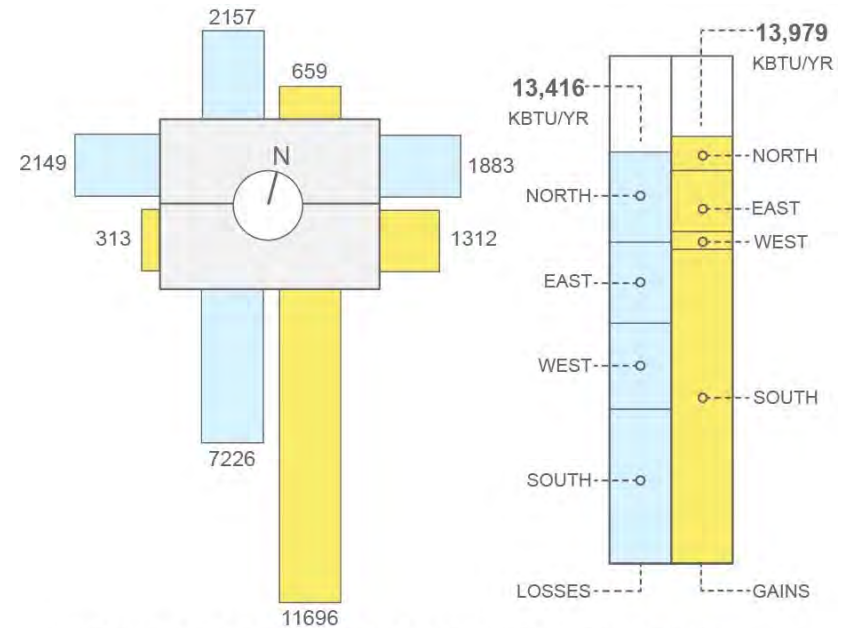
HEATING AND COOLING

DOMESTIC HOT WATER

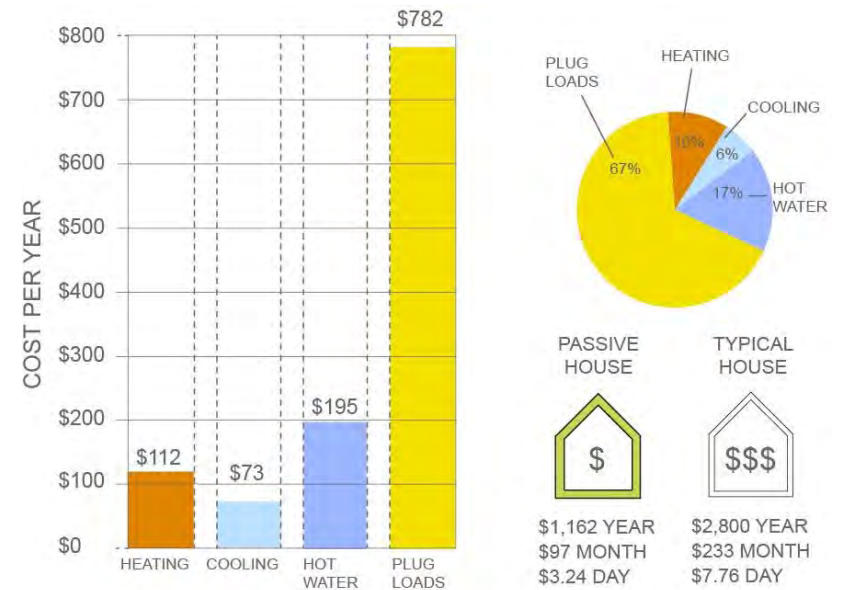
ZEHNDER ERV

12KBTU MITSUBISHI

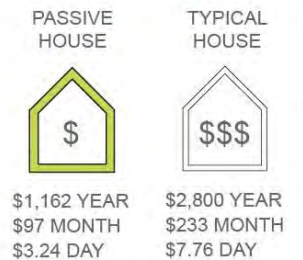
NYLES GEYSER HWHP



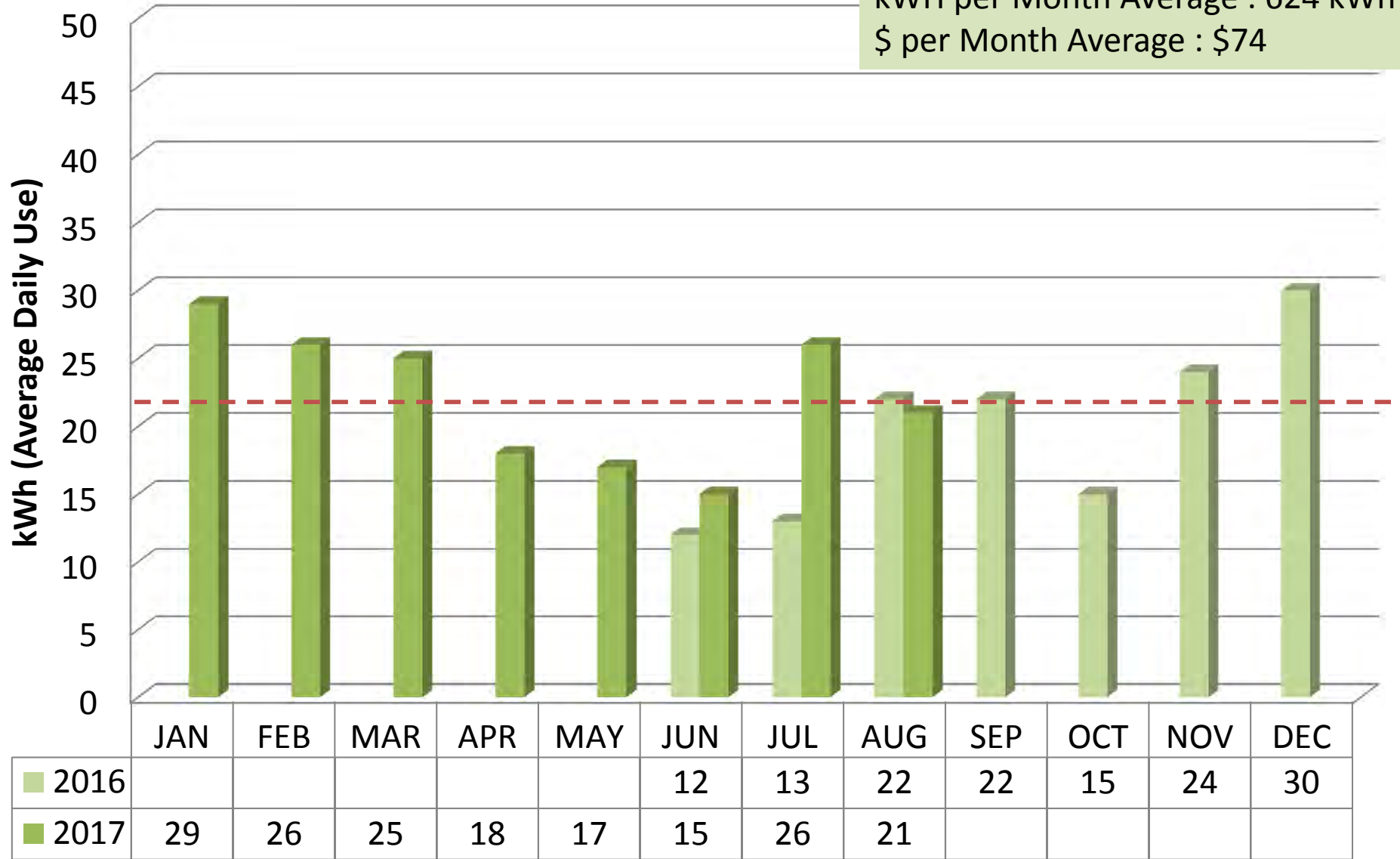
GLAZING SOLAR GAINS AND LOSSES BY ORIENTATION



OPERATING EXPENSE



kWh per Month Average : 624 kWh
 \$ per Month Average : \$74



--- Year Average

KEFFER PASSIVE HOUSE

PHIUS certification



Passive House homeowners

Lyn and Tom Keffer

KEFFER PASSIVE HOUSE

“The house is very comfortable.”

Lynn Keffer



KEFFER PASSIVE HOUSE

“The passive house structure’s large south-facing windows provide lots of natural light.”

Lynn Keffer




KEFFER PASSIVE HOUSE



“Whenever we arrive the inside air feels fresh, without musty odors.”

Lynn Keffer

KEFFER PASSIVE HOUSE

The image shows a bright, open-plan living and dining area. In the foreground, a wooden dining table with a colorful patterned runner is surrounded by brown leather chairs. Behind it is a kitchen with white cabinetry and a dark countertop. To the left, a wooden staircase with a metal railing leads to an upper level. Large windows and a glass door provide ample natural light and views of the outdoors. The ceiling features a track lighting system with several pendant lights.

“We have found that the house requires minimal maintenance.”

Lynn Keffer

KEFFER PASSIVE HOUSE



“The house holds temperatures very well, so we don't have to constantly monitor a thermostat in response to changes in outdoor temperature.”

Lynn Keffer

KEFFER PASSIVE HOUSE



“Amazingly, even with a few windows open the interior temperature doesn’t change much.”

Lynn Keffer

KEFFER PASSIVE HOUSE



“The house can be very quiet.”
Lynn Keffer



KEFFER PASSIVE HOUSE

“The outdoor fireplace on the screened porch is great visually and it is wonderful on cooler nights in the summer, early fall, and late spring.”

Tom Keffer

KEFFER PASSIVE HOUSE



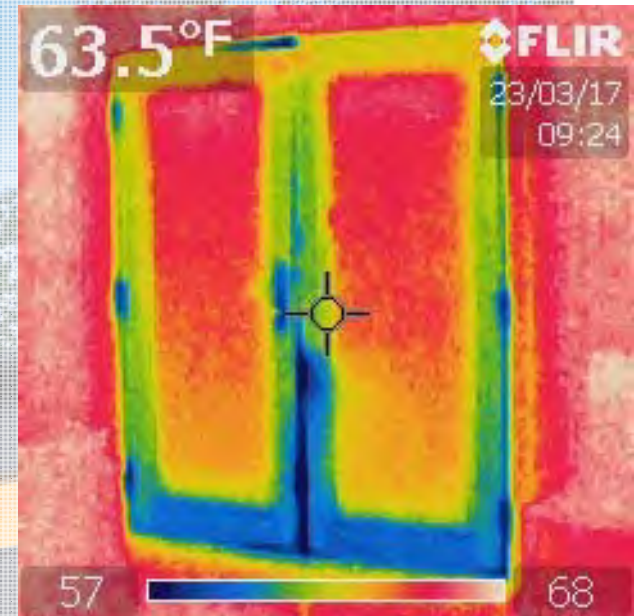
KEFFER PASSIVE HOUSE

LESSONS LEARNED

1. Humidity control is a problem
2. Windows / doors leak air
3. Nyles Geyser HWHP is noisy

Why its not certified

1. Washer not Energy Star
2. Hot water fails circulation test



SOEDER PASSIVE HOUSE

“My wife and I wanted to build a new home that would suit us now and into retirement. I also wanted to achieve a high level of sustainability and take advantage of the latest building technology.”

Shawn Soeder, homeowner



PROJECT INFORMATION

LOCATION

SIZE

CLIMATE ZONE

HERS

CONSTRUCTION

COST

MODELING TOOLS

MONITORING

PV TO NET ZERO

BECHTELSVILLE, PA

2,600 SQFT.

5/6 COLD

30

COMPLETE 2016

\$136/SQFT.

PHPP / REMRATE

PHIoT

6KW TO 8

RPA PH GEOMETRY

ENVELOPE AREA TO TFA

SURFACE AREA TO VOLUME

ENVELOPE AREA TO GLAZING

SOUTH GLAZING

ENCLOSURE R-VAULE

3

32

14%

51%

38.5

PASSIVE HOUSE METRICS

ANNUAL HEAT DEMAND

HEAT LOAD

PRIMARY ENERGY

AIR TIGHTNESS

TREATED FLOOR AREA

4.75 KBTU/(FT2YR)

2.84 KBTU/(FT2YR)

34.5 KBTU/(FT2YR)

0.22ACH@50PA

2,440 SQFT.

CONSTRUCTION SPECS

FLOOR

WALLS

ROOF

WINDOWS

R=42 CRAWL SPACE

R=60 2X4 WALL PLUS TJI

R=100 ENERGY TRUSS

R=7 INTUS EFORTE

MECHANICAL SYSTEMS

VENTILATION

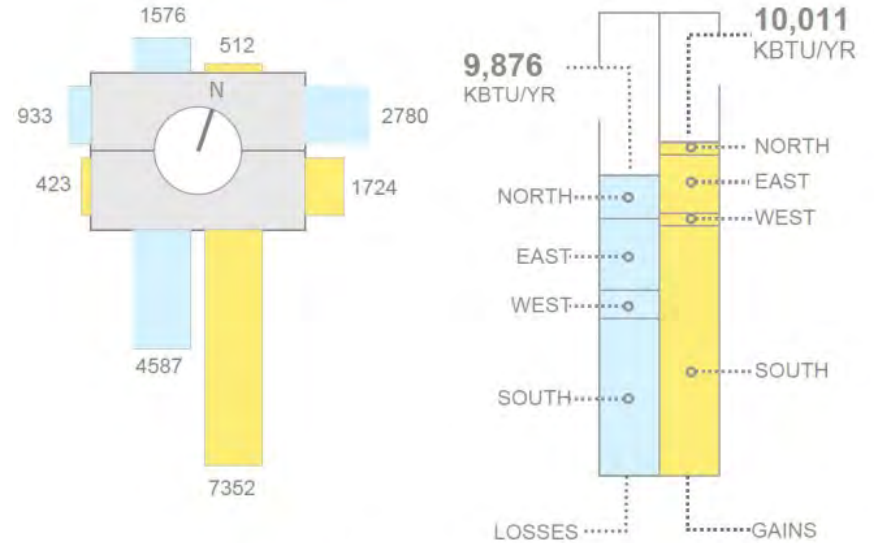
HEATING AND COOLING

DOMESTIC HOT WATER

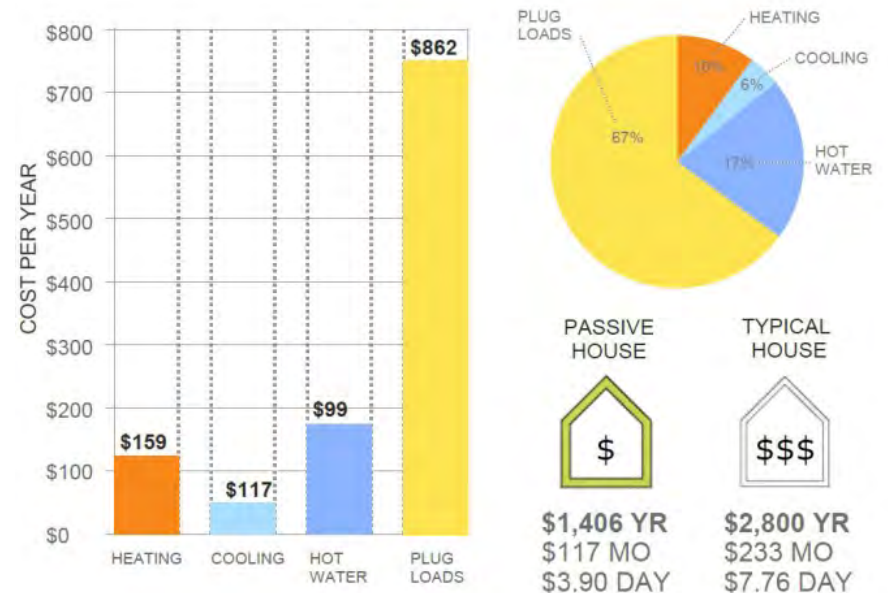
ZEHNDER ERV

12KBTU MITSUBISHI ASHP

GE HWHP

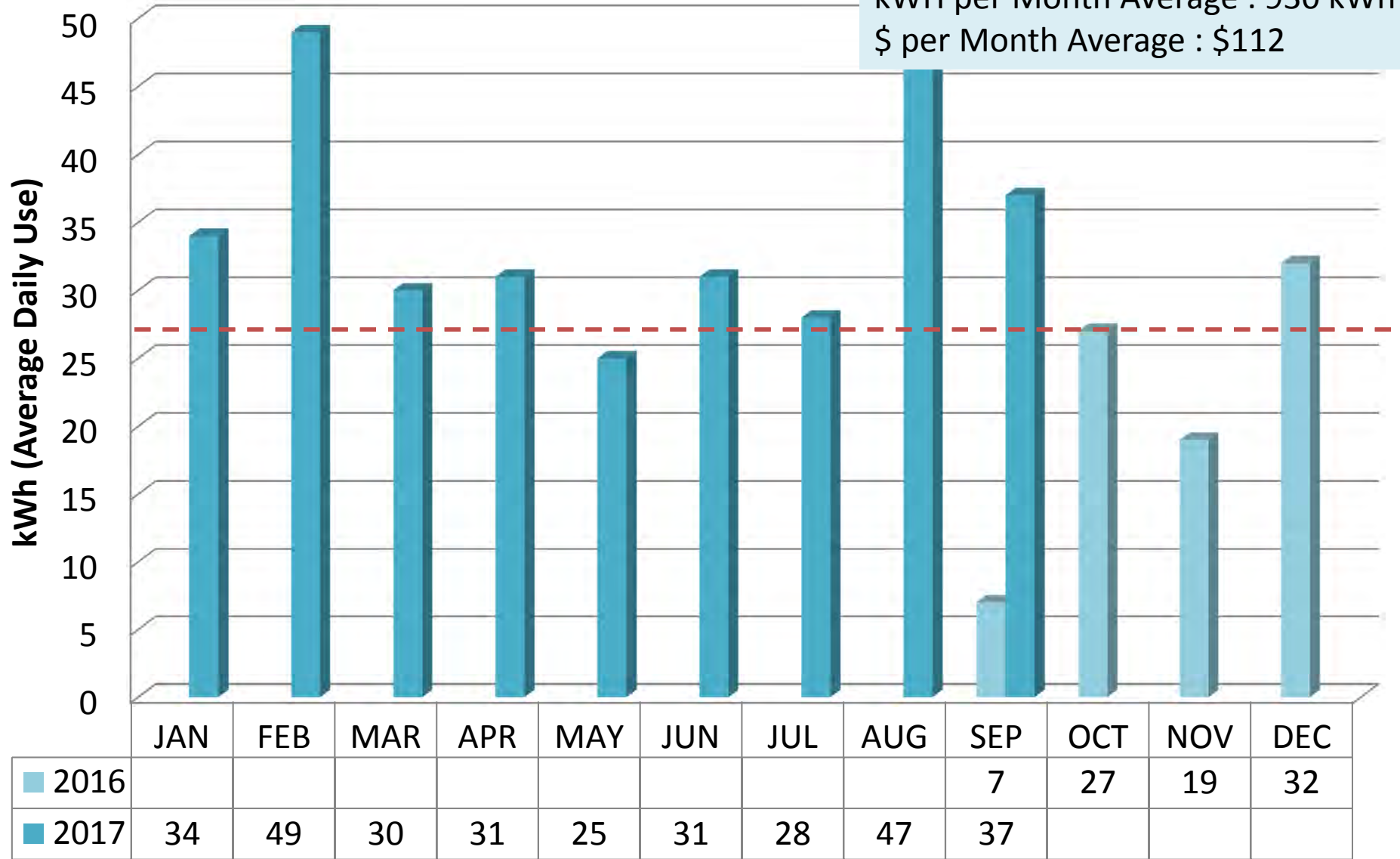


GLAZING SOLAR GAINS AND LOSSES BY ORIENTATION



OPERATING EXPENSE

kWh per Month Average : 930 kWh
 \$ per Month Average : \$112



--- Year Average

SOEDER PASSIVE HOUSE

The #143 PHIUS certified Passive House in North America



Passive House homeowners

JeanAnn and Shawn Soeder

SOEDER PASSIVE HOUSE

”Our house has been extremely comfortable! Both my wife and I feel the main living spaces tend to be the right temperature and humidity through all the seasons. We do have one upstairs bedroom that tends to be too warm at times, and that takes some attention (door open during the day, sometimes use a fan).”

Shawn Soeder



SOEDER PASSIVE HOUSE

“My favorite thing is the **peace of mind** that comes with a high performance building, knowing that we didn't compromise when it comes to the environmental impact.

Shawn Soeder



SOEDER PASSIVE HOUSE

“JeanAnn doesn't like the ventless dryer”

Shawn Soeder



SOEDER PASSIVE HOUSE



“We feel that we have **cleaner air** than a normal house. We don't smell odors within the house except, temporarily from cooking food.”

Shawn Soeder

SOEDER PASSIVE HOUSE

Also, we haven't install the screens. I don't like how the screens fit into the Intus windows and this keeps us from opening them as often as we'd like.”

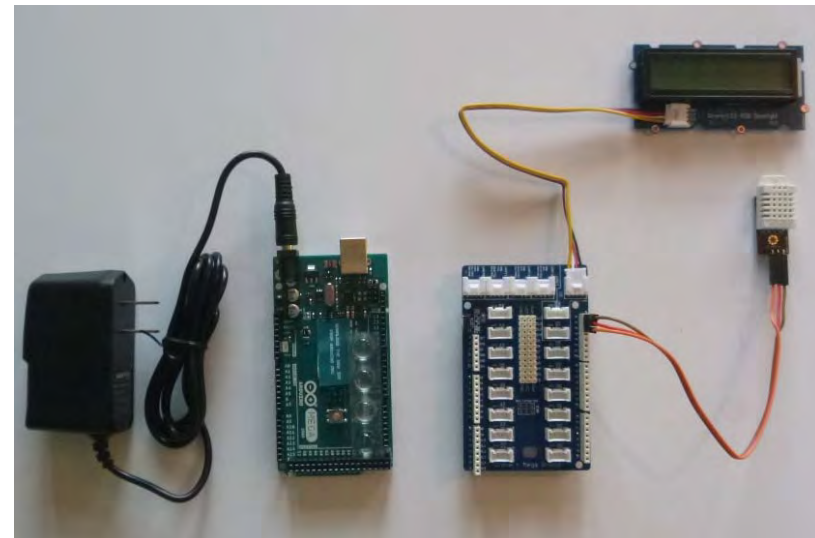
Shawn Soeder



SOEDER PASSIVE HOUSE

LESSONS LEARNED

1. PHIUS +
2. A Passive House Arduino based **IoT monitoring system**
3. Self build cost = **\$136 sf**





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