ENERGY DESIGN
conference & expo

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DESIGNER
CERTIFIED PASSIVE HOUSE DESIGNER

Residential Passive House Retrofit (EnerPHit)

The MinnePHit House

Case Study about the first cold-climate EnerPHit project in the World

Tim Eian, Dipl.-Ing., Certified Passive House Planner & Consultant

In accordance with the Department of Labor and Industry's statute 326.0981, Subd. 11,

"This educational offering is recognized by the Minnesota Department of Labor and Industry as satisfying **1.5 hours** of credit toward **Building Officials and Residential Contractors code/energy** continuing education requirements."

For additional continuing education approvals, please see your credit tracking card.

Learning Objectives

- The Passive House building energy standards
- Residential Passive House retrofit design
- Strategies, materials and systems
- Challenges & Opportunities
- Certification

Introduction

The MinnePHit House
Minneapolis, MN

EnerPHit
Quality-Approved
Energy Retrofit with
Passive House Components
Dr. Wolfgang Feist

Photos: Corey Gaffer

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before

after

before

after

Photos: Corey Gaffer

before


after
Photos: Corey Gaffer

Minneapolis

+ EnerPHit

= MinnePHit

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The
Passive House Standard

Passivhaus - Passive House

"A rigorous, voluntary building energy standard focusing on highest energy efficiency and quality of life at low operating cost."

Passive House in 90 Seconds

Video: Hans-Jörn Eich

Global Standard

Think globally, build locally.

Global Adoption

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Third-Party Certified

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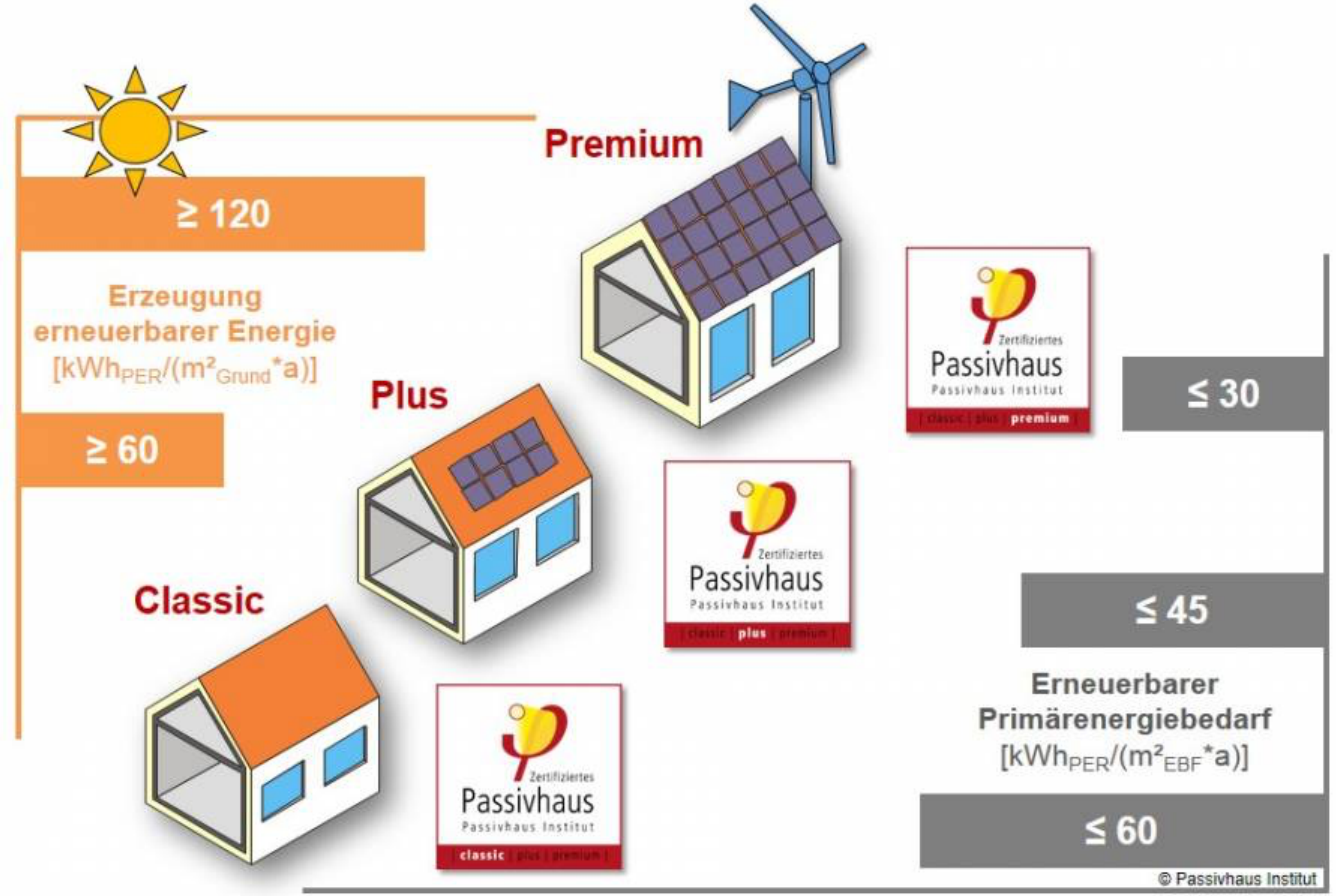
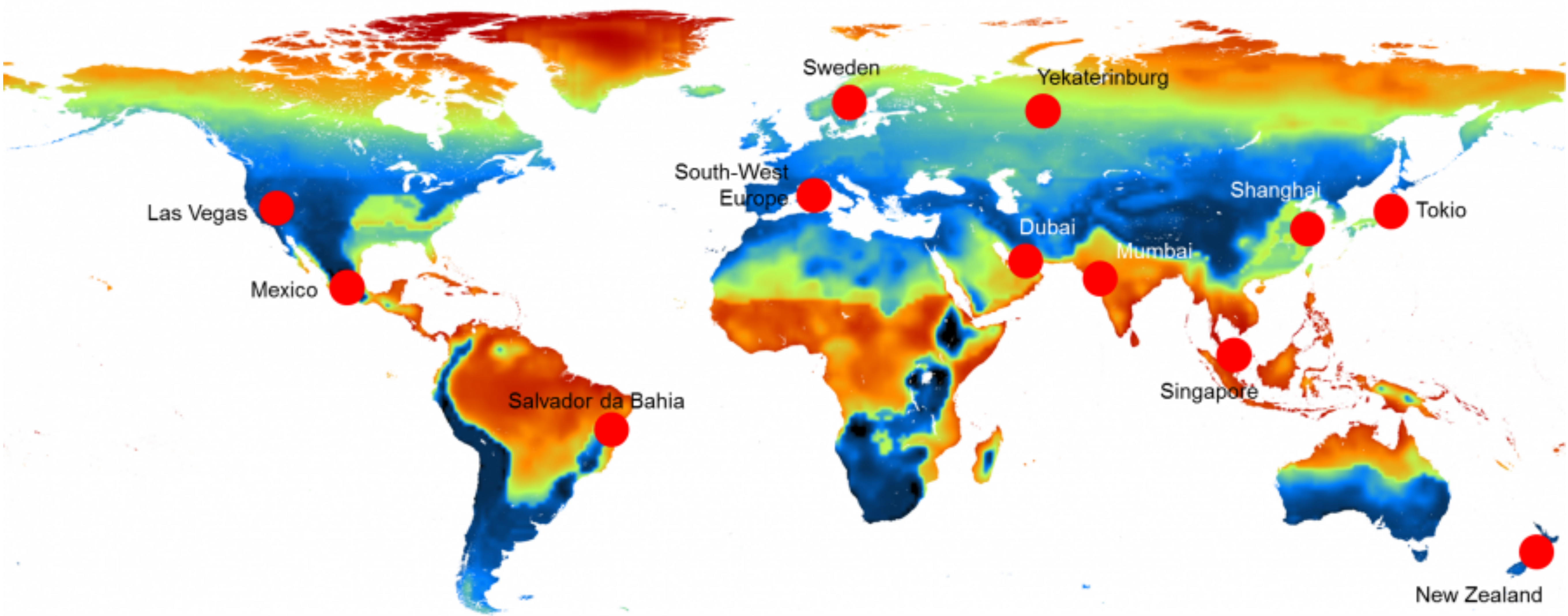
Tool

The Path to Ultimate Sustainability



Global Climate Specificity



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Climate-Specific Requirements

Climate zone according to PHPP	Opaque envelope[1] against... ...ground: Insulation	...ambient air: Exterior insulation	...ambient air: Interior insulation[2]	...ambient air: Exterior paint[3]	Windows (including exterior doors): Overall[4]			Glazing[5]	Solar load[6]	Ventilation	
	Max. heat transfer coefficient (U-value)			Cool colours	Max. heat transfer coefficient ($U_{D/W,installed}$)			Solar heat gain coefficient (g-value)	Max. specific solar load during cooling period	Min. heat recovery rate[7]	Min. humidity recovery rate[8]
	[W/(m²K)]			-	[W/(m²K)]			-	[kWh/m²a]	%	
Arctic	Determined in PHPP from project specific heating and cooling degree days against ground.	0.09	0.25	-	0.45	0.50	0.60	$U_g - g*0.7 \le 0$	100	80%	-
Cold		0.12	0.30	-	0.65	0.70	0.80	$U_g - g*1.0 \le 0$		80%	-
Cool-temperate		0.15	0.35	-	0.85	1.00	1.10	$U_g - g*1.6 \le 0$		75%	-
Warm-temperate		0.30	0.50	-	1.05	1.10	1.20	$U_g - g*2.8 \le -1$		75%	-
Warm		0.50	0.75	-	1.25	1.30	1.40	-		-	-
Hot		0.50	0.75	Yes	1.25	1.30	1.40	-		-	60 % (humid climate)
Very hot		0.25	0.45	Yes	1.05	1.10	1.20	-		-	60 % (humid climate)

Energy Modeling

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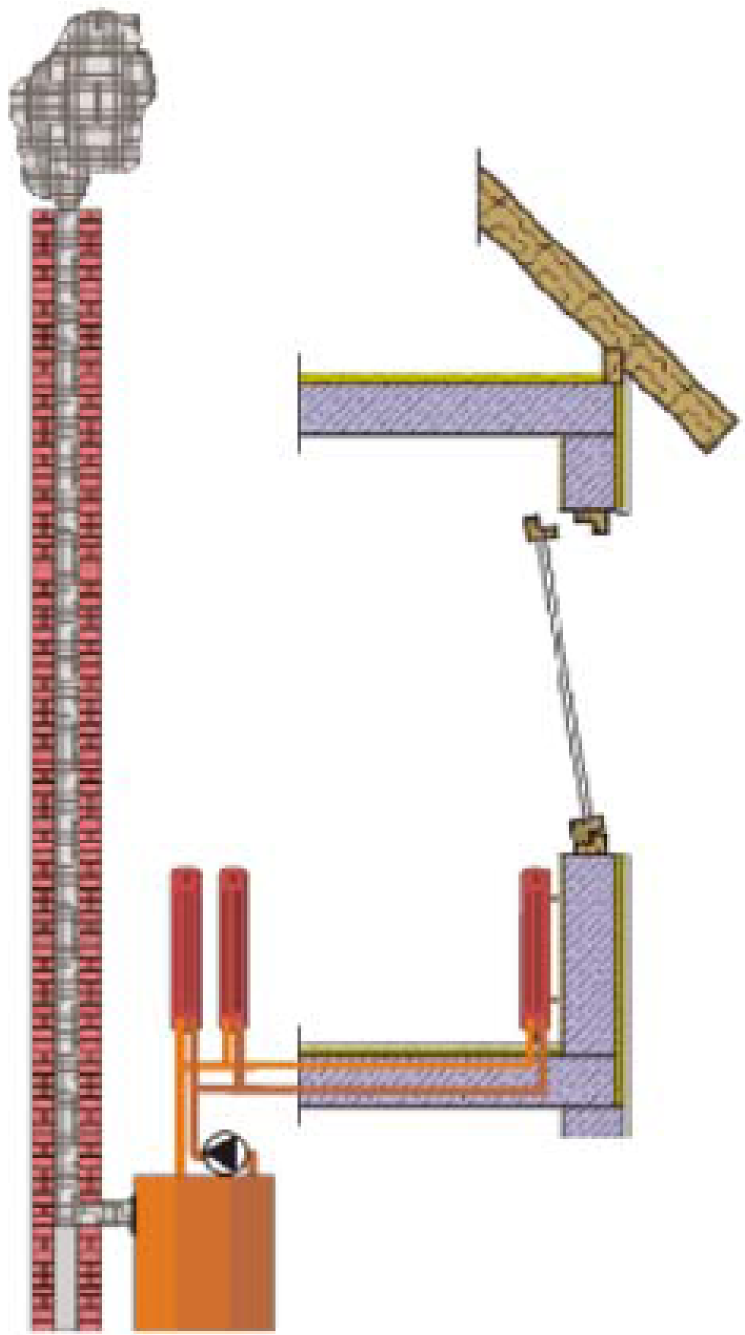
Basic Concept

Conservation first

➡ Minimize losses

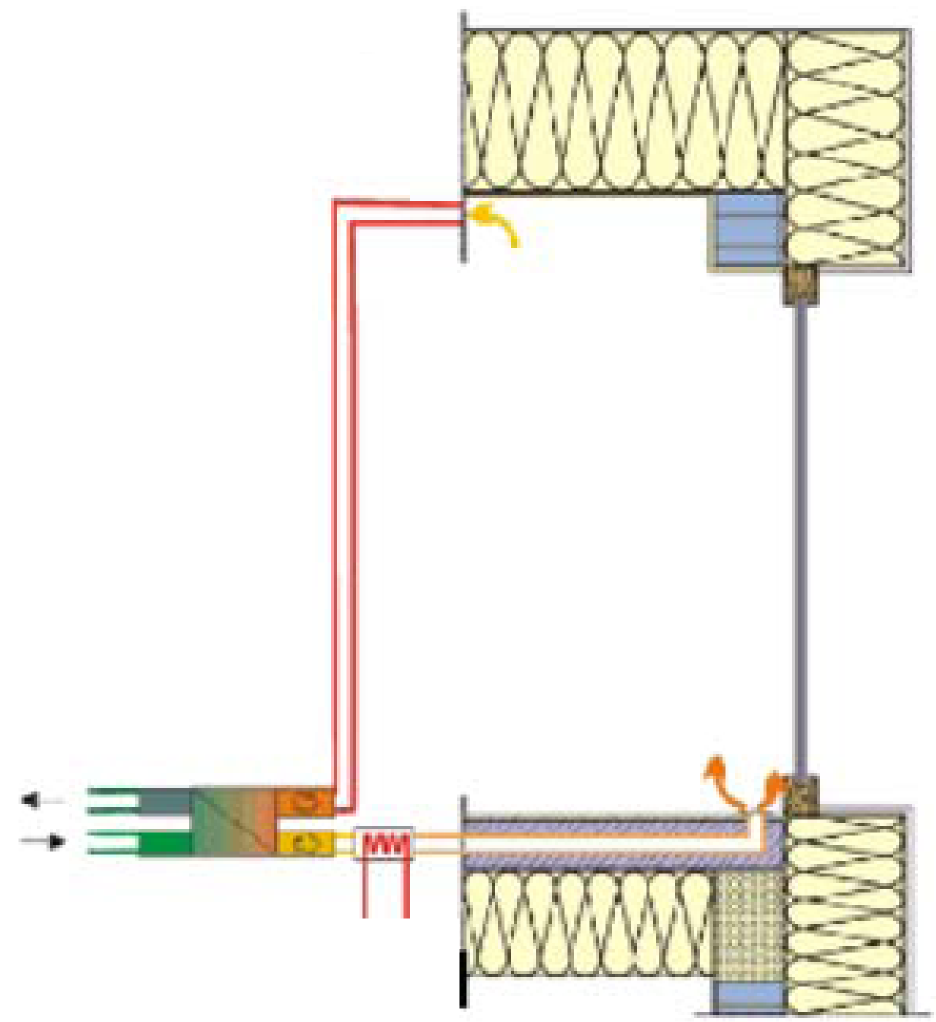
➡ Maximize (free) gains

Active vs. Passive



Active: 25-125 kBtu/(sf yr)

85 - 450 kWh/(m^2 a), typically found in the U.S.



Passive: 4.75 kBtu/(sf yr)

15kWh/(m^2 a), maximum target

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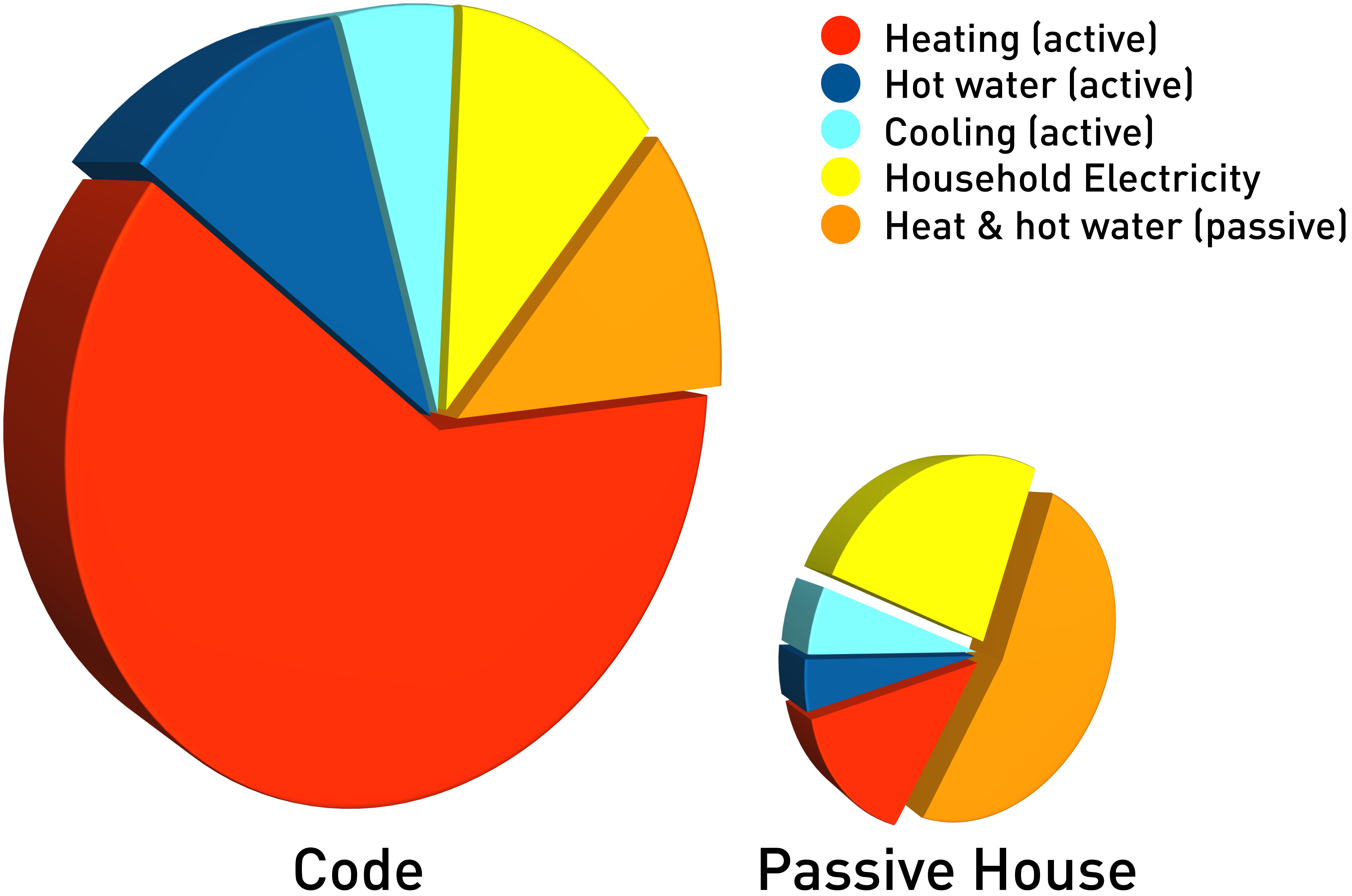
Source: Krapmeier & Drössler 2001

Energy Footprint



➡ up to 95% less heating energy

➡ 50 to 75% less total energy

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Metrics

Energy per Square Foot and Year

Gas mileage for buildings.

Space Conditioning Energy Targets

≤ 4.75 kBtu/(sf yr)

≤ 15kWh/(m^2 a)

≤ 9.5 kBtu/(sf yr)

≤ 30kWh/(m^2 a)

≤ 7.9 kBtu/(sf yr)

≤ 25kWh/(m^2 a)

Total energy used to heat or cool a building.

Source Energy Targets

PHI Low Energy Building

≤ 38 kBtu/(sf yr)

$\leq 120 kWh/(m^2 a)$

EnerPHit
Quality-Approved Energy Retrofit with Passive House Components
Dr. Wolfgang Feist

varies

$\leq 120\ kWh/(m^2\ a) + ((QH - 15\ kWh/(m^2\ a)) * 1.2)$

Total energy used to heat or cool a building.

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Heating Load Target (suggested)

≤ 3.17 Btu/(h sf)

≤ 10W/m^2

Heating energy can be supplied through ventilation system.

Airtightness Targets

$\leq 0.6\ ACH_{50}$

PHI Low Energy Building

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$\leq 1.0\ ACH_{50}$

Measured with a blower door in the field.

Component Targets

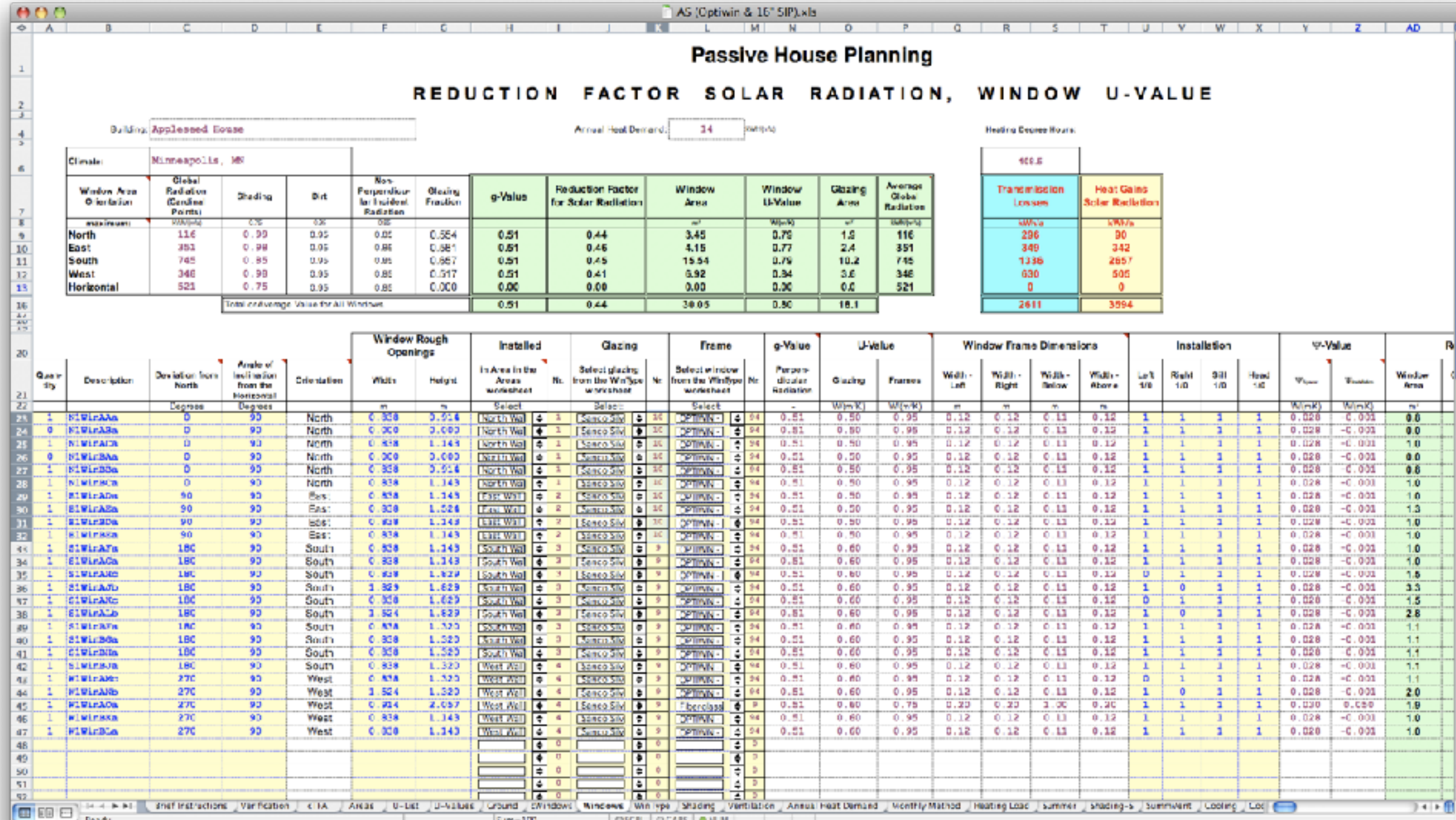
- Maximum U-values
- Minimum R-values
- SHGC requirements
- Minimum heat-recovery rates

EnerPHit offers a Component Track.

Component Targets

Climate zone	Hygiene[1]	Comfort[2]			
	Min. temperature factor	Max. thermal transfer coefficient			
	$f_{Rsi=0.25\ m^2K/W}$	U-value			
	[]	[W/(m²K)]			
Arctic	0.80	0.45	0.50	0.60	0.35
Cold	0.75	0.65	0.70	0.80	0.50
Cool-temperate	0.70	0.85	1.00	1.10	0.65
Warm-temperate	0.60	1.10	1.15	1.25	0.85
Warm	0.55	-	1.30	1.40	-
Hot	-	-	1.30	1.40	-
Very hot	-	-	1.10	1.20	-

Predictable Outcome & Measurable Results



AS (Optiwin & 16" SIP).xls

Passive House Planning

REDUCTION FACTOR SOLAR RADIATION, WINDOW U-VALUE

Building: Appleseed House | Annual Heat Demand: 14 kWh/(m²a) | Heating Degree Hours: 400.6

Climate: Minneapolis, MN

Window Area Orientation	Global Radiation (Cardinal Points)	Shading	Dirt	Non-Perpendicular Incident Radiation	Glazing Fraction	g-Value	Reduction Factor for Solar Radiation	Window Area	Window U-Value	Glazing Area	Average Global Radiation	Transmission Losses	Heat Gains Solar Radiation
North	116	0.99	0.95	0.85	0.554	0.51	0.44	3.45	0.79	1.9	116	296	90
East	351	0.98	0.95	0.85	0.581	0.51	0.46	4.15	0.77	2.4	351	349	342
South	745	0.85	0.95	0.85	0.657	0.51	0.45	15.54	0.79	10.2	745	1336	2657
West	346	0.98	0.95	0.85	0.517	0.51	0.41	6.92	0.84	3.6	346	630	505
Horizontal	521	0.75	0.95	0.85	0.000	0.00	0.00	0.00	0.00	0.0	521	0	0
Total or Average Value for All Windows						0.51	0.44	30.05	0.80	18.1		2611	3594

Passive House Planning Package - PHPP

Key Benefits

Highest Comfort

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Superior Indoor Environmental Quality

Ecology and Resource Efficiency

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Image Source: dreamstime.com

Cheapest Life Cycle Cost

Image Source: dreamstime.com

The
MinnePHit Project

Where are we?

what we got

Image Source: carlustblog.org

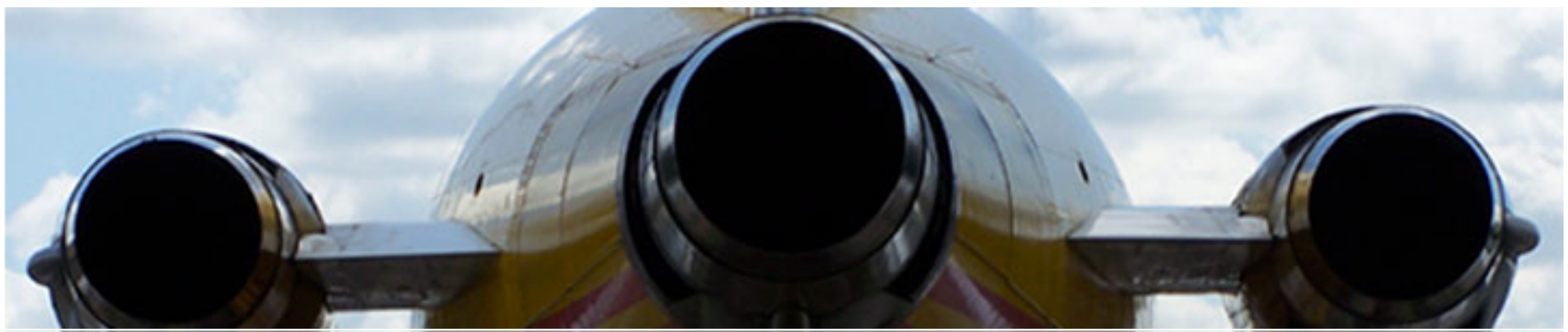
1935

- 2 stories + basement
- 1,200 finished SF
- 2 bedrooms
- 1 bath
- 5 people

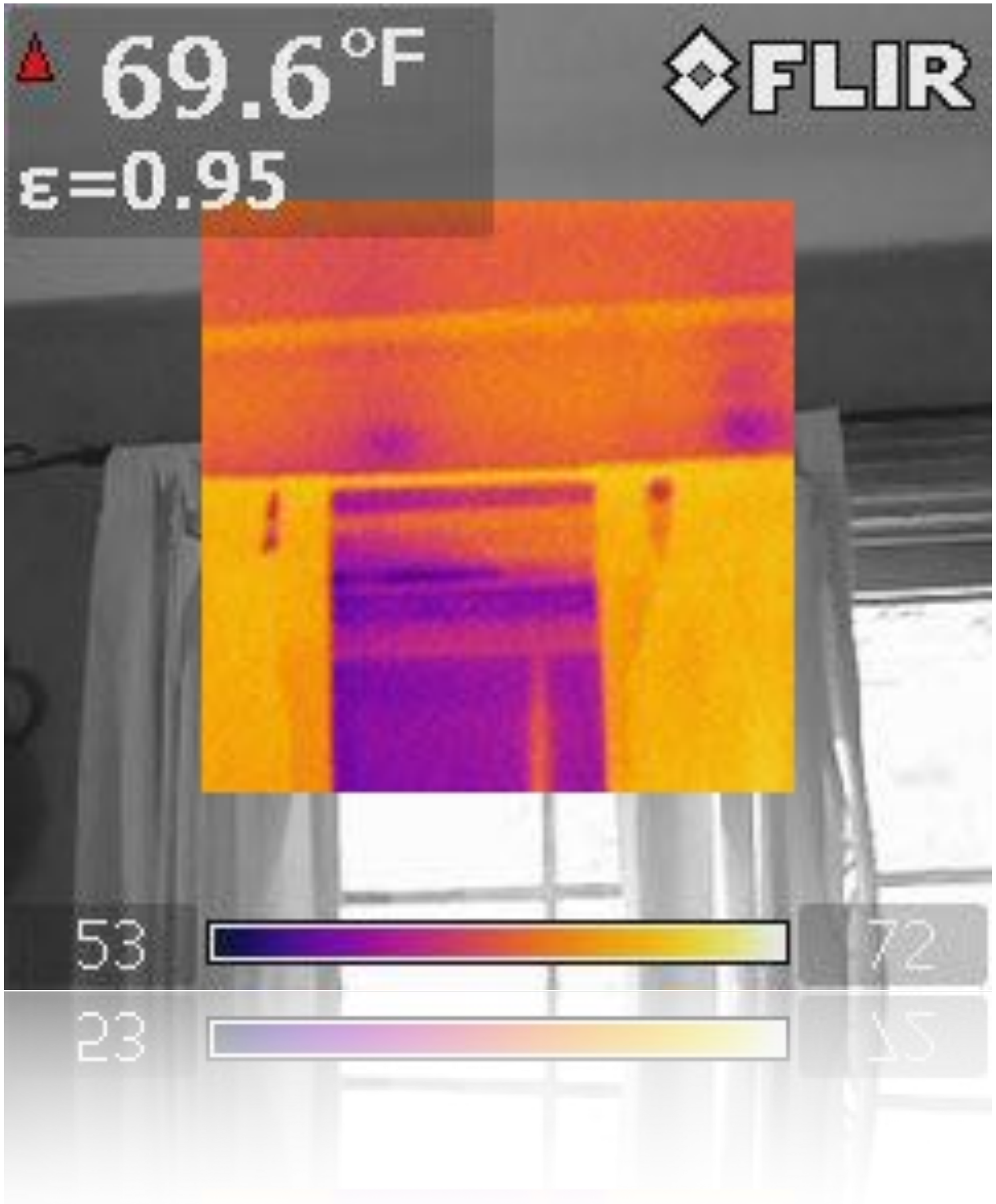


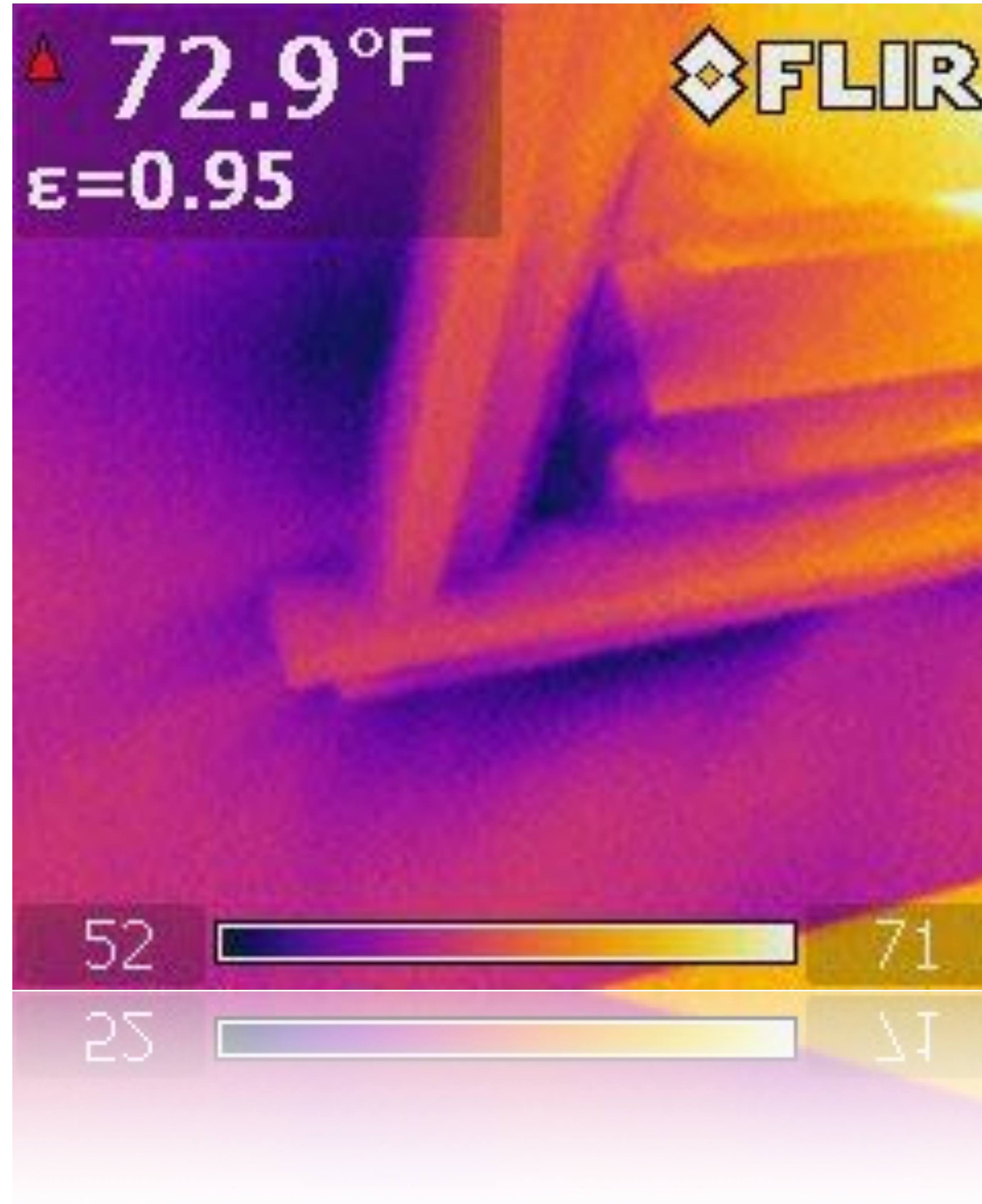
A P M

Prior Airport Noise Retrofit

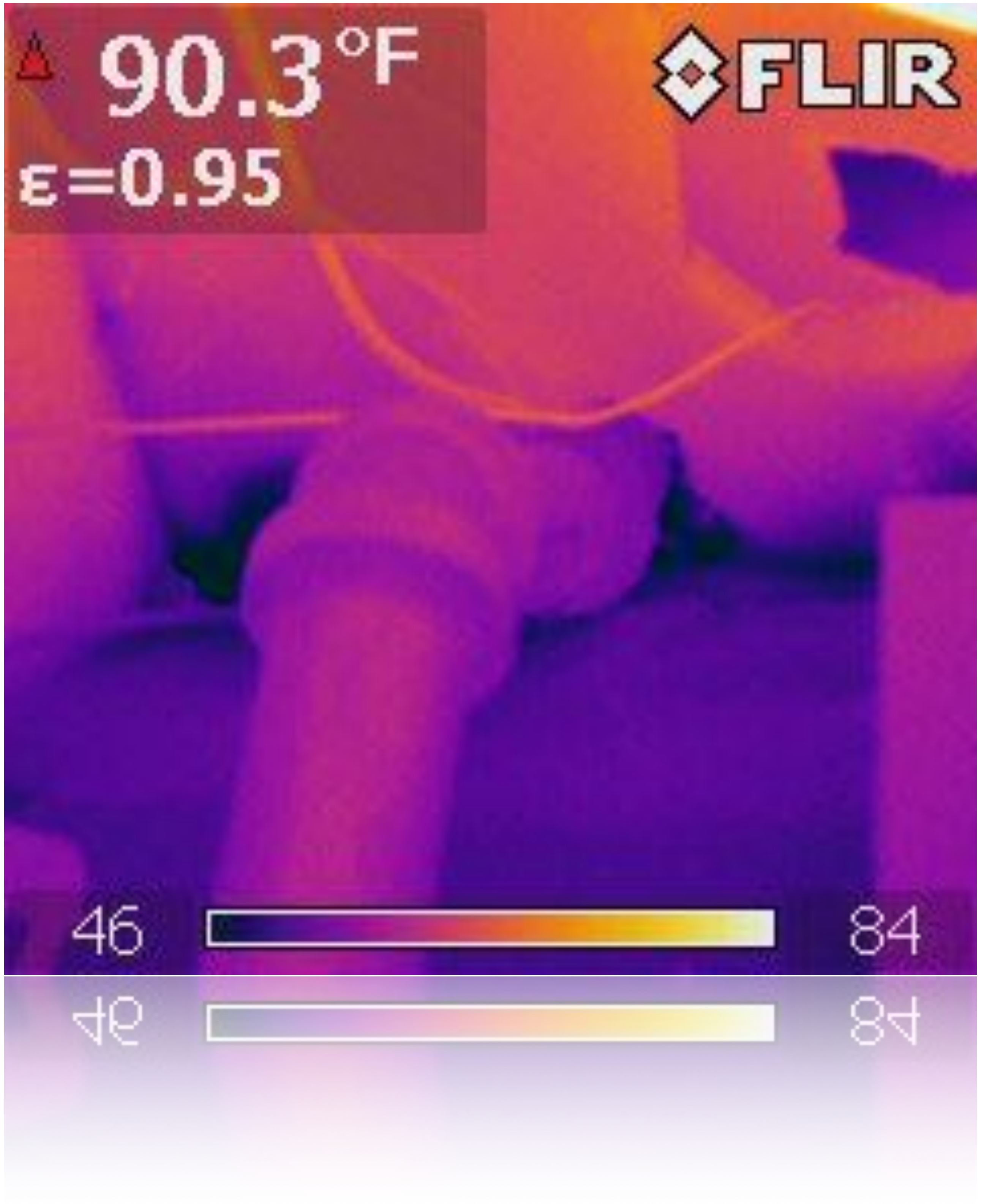


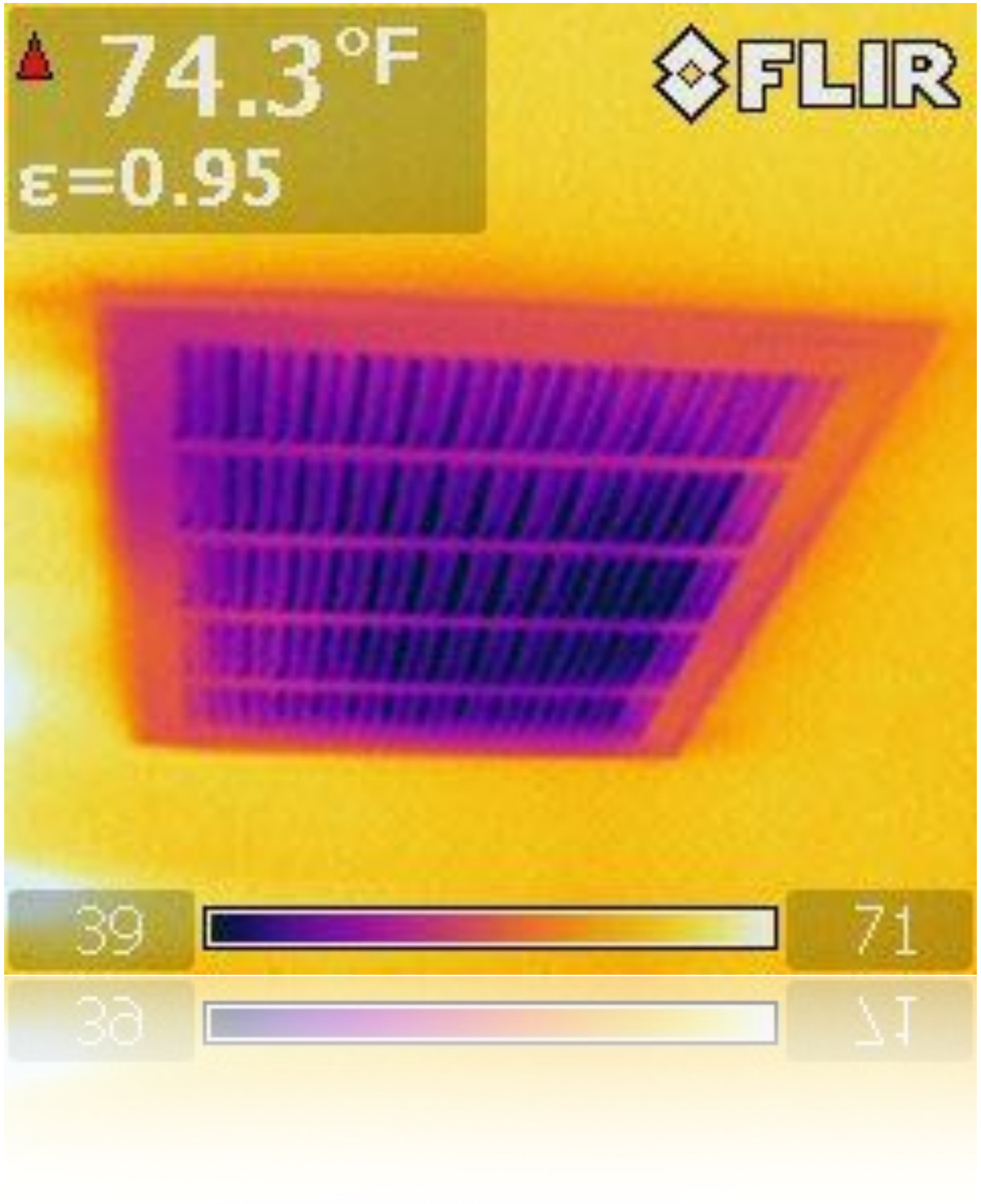
Windows with Storms





Mechanicals



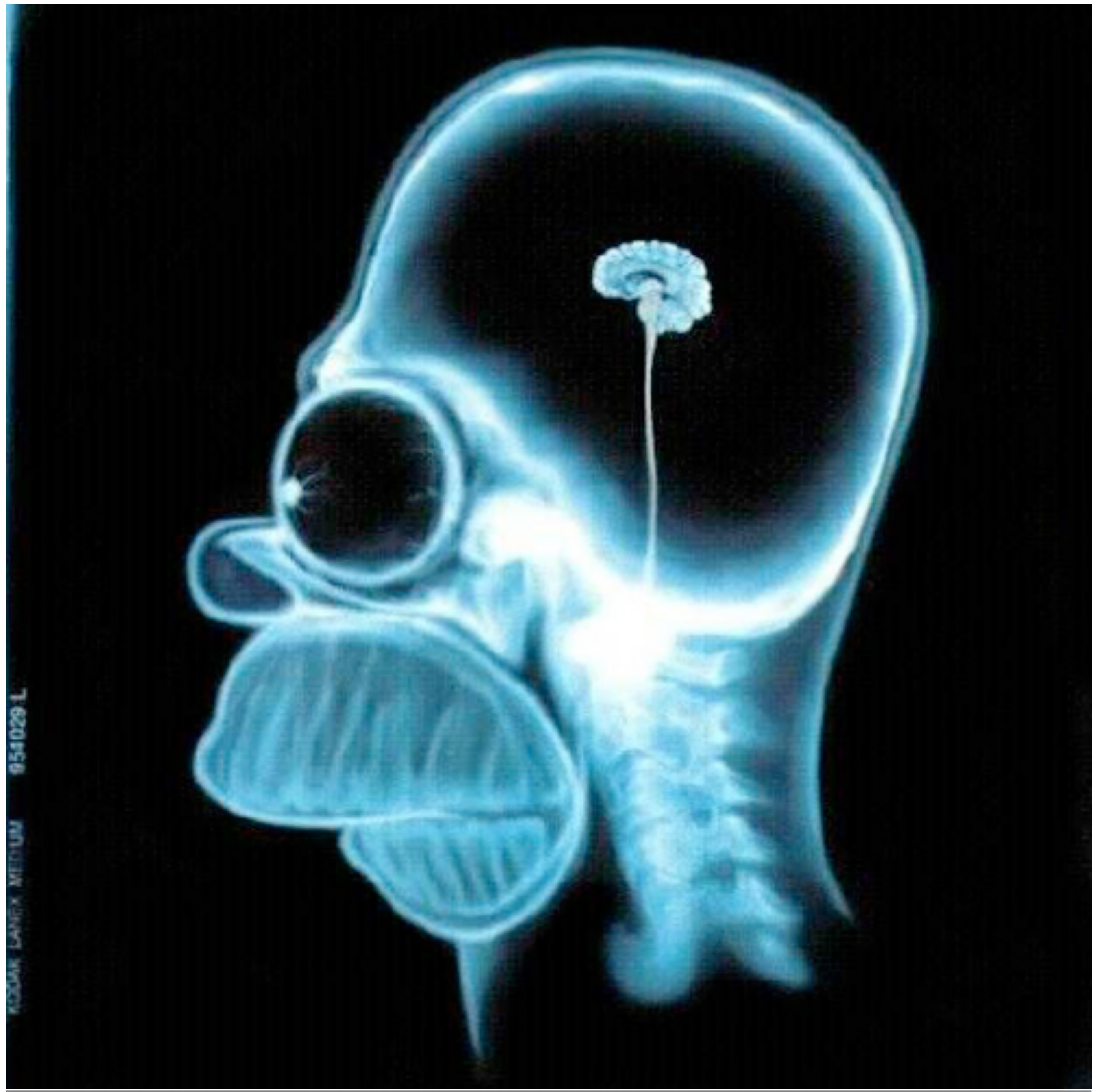


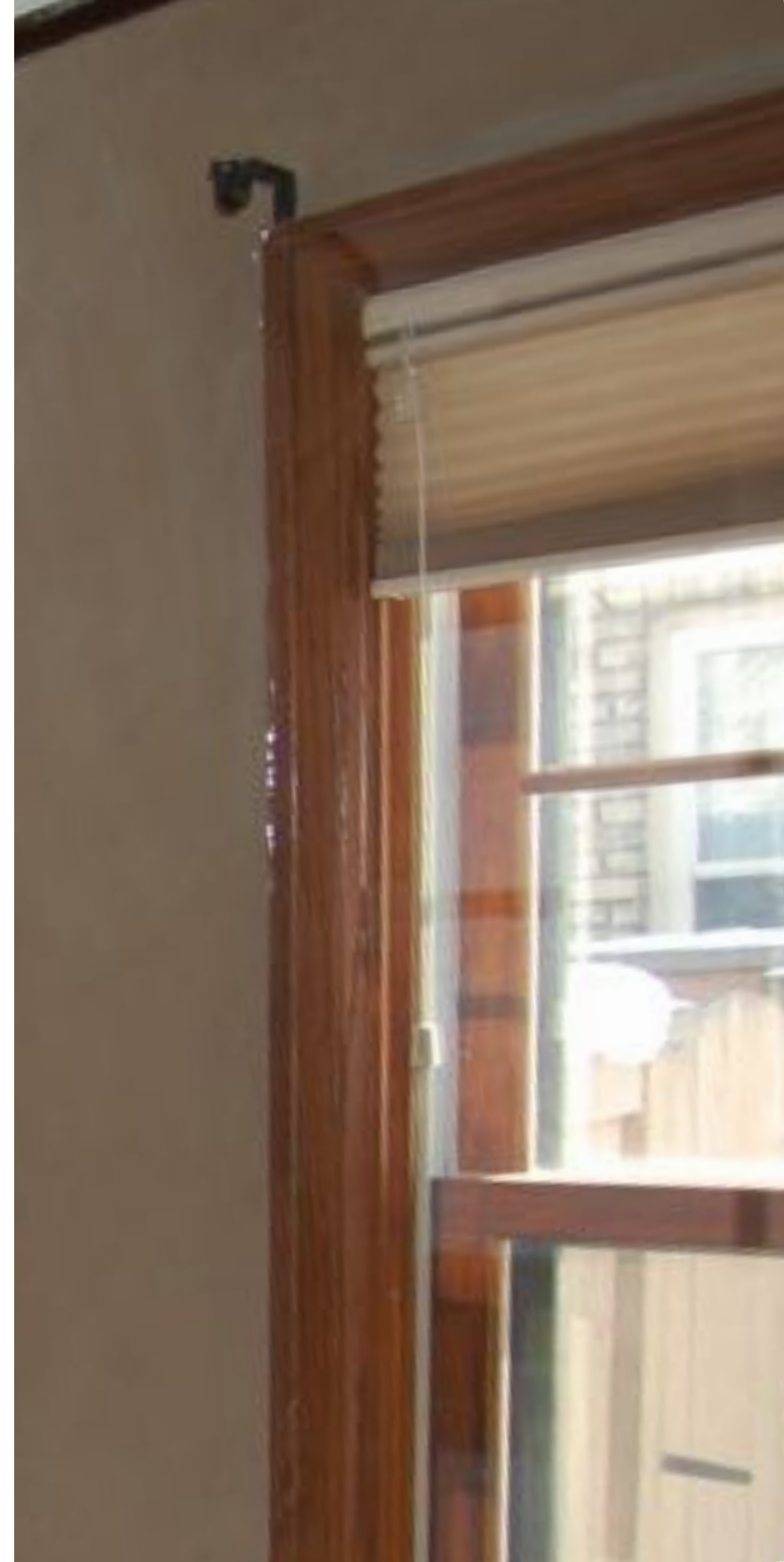
Airtightness

Initial Test

8.5 ACH_{50} [2,100 CFM_{50}]

Pre-Existing Conditions



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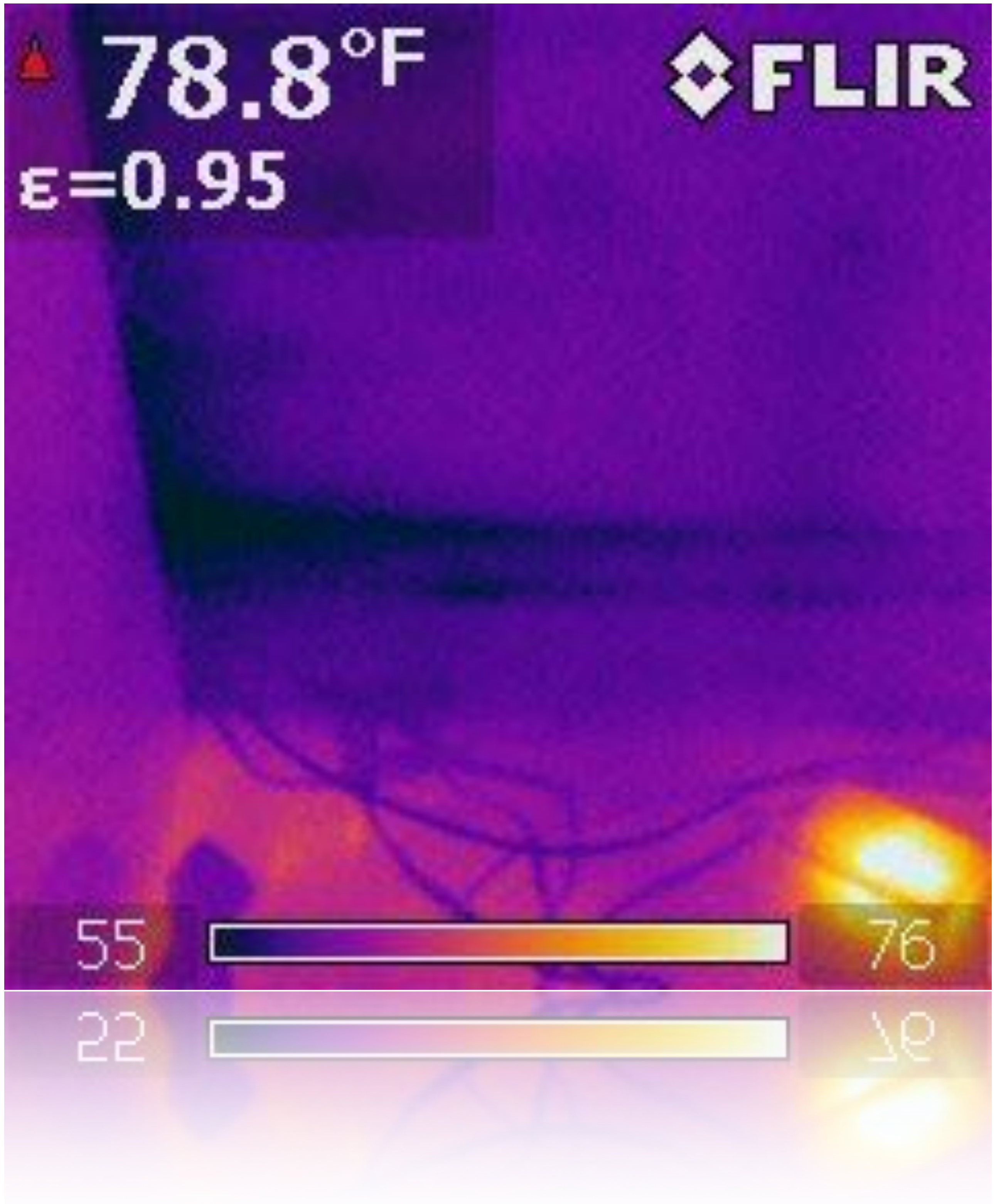
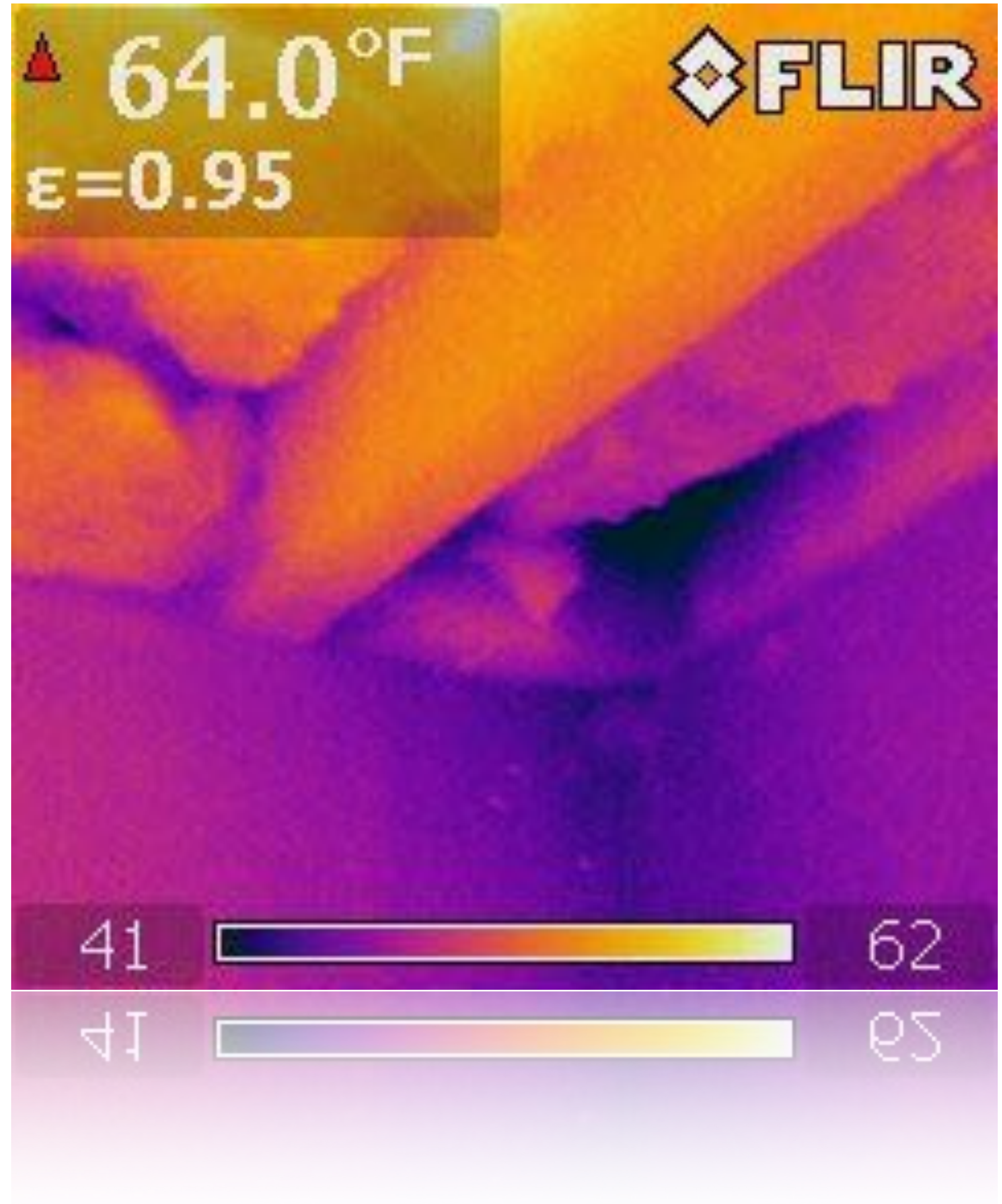
G -$944
$1526.50
War is a Force That Gives Us Meaning


T-K3


78.8°F
ε=0.95
FLIR
55
76


64.0°F
ε=0.95
FLIR
41
62

So, Where Are We?

- Structure ✓
- Weather Barrier?
- Insulation ✗
- Airtightness ✗
- Moisture Management ✓
- Ventilation/ Air Quality ✗
- Comfort ✗ ✗
- Daylight ✗
- Durability (30 years?)
- Design (Sign of the Times)

Where do we go?

what we need

Image Source: Wikipedia

The List

- + 3 Bedrooms
- + 2 Baths
- + Mudroom
- Better kitchen
- Better living areas
- Homeschool room
- Safe stairs
- Weather-tight envelope
- Durable structure
- Healthy interiors
- Comfort & daylight
- Low operating cost
- Energy performance

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Energy Retrofit with
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Dr. Wolfgang Feist


TOKAI
SHARP
60

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Dr. Wolfgang Feist
Rheinstraße 44/46
64283 Darmstadt
Germany
www.passivehouse.com

EnerPHit and EnerPHit^{+i}

Certification Criteria for Energy Retrofits with Passive House Components

If an energy retrofit of an existing building meets Passive House criteria (for new builds), it, too, can be certified as a Certified Passive House.

It is, however, often difficult to feasibly achieve the Passive House Standard in older buildings for a variety of reasons. Passive House technology for relevant building components in such buildings does, nevertheless, lead to considerable improvements with respect to thermal comfort, structural longevity, cost-effectiveness over the building lifecycle and energy use.

Buildings that have been retrofitted with Passive House components and, to a great extent, with exterior wall insulation can achieve EnerPHit certification as evidence of both building quality and fulfilment of specific energy values. The EnerPHit^{+i} designation is applied if more than 25 % of the opaque exterior wall surface has interior insulation.

How do we get there?

Holistic Energy Reduction Retrofit

≠

Weatherization

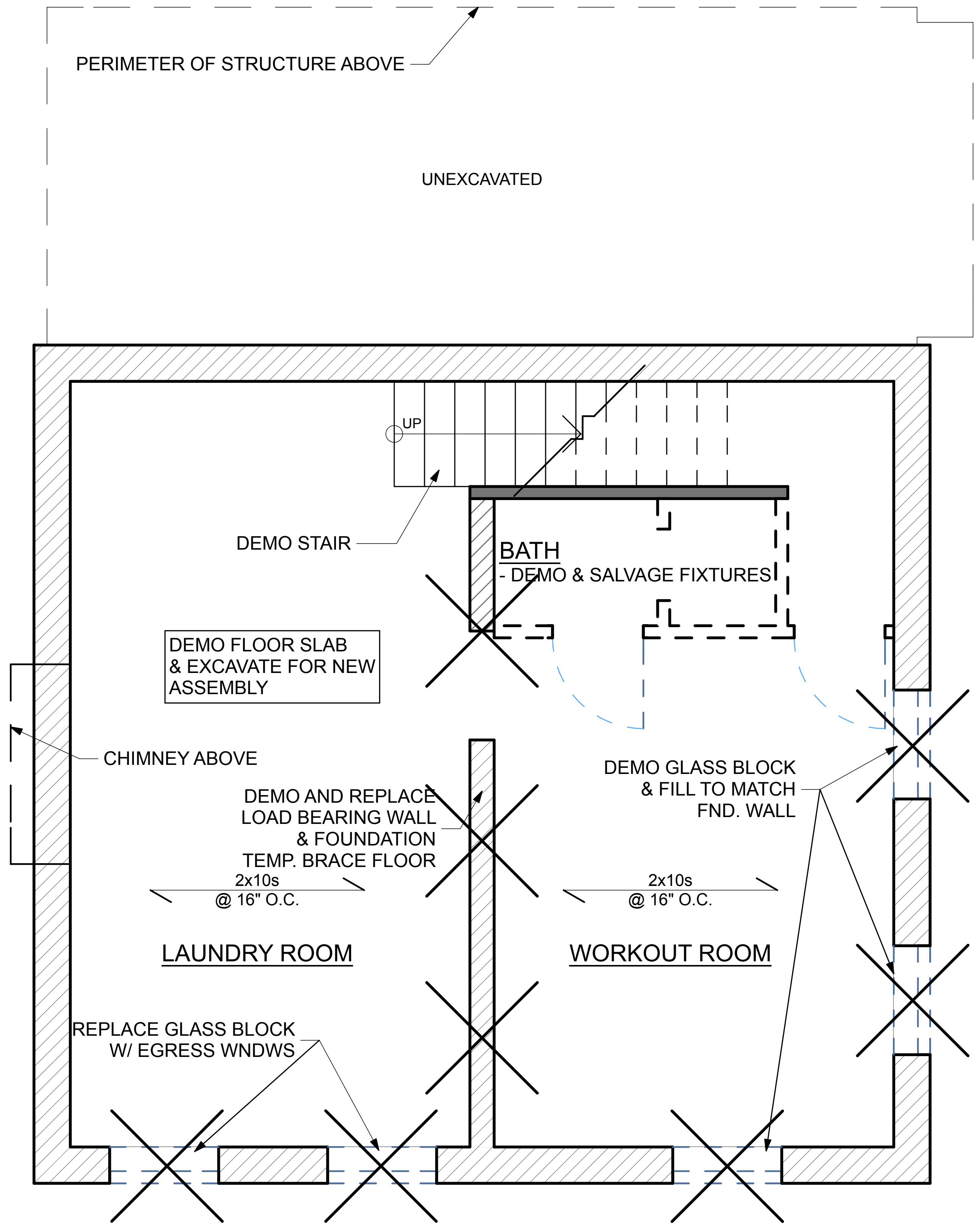
Sports car?

The Plan for Success

- Set goals for performance and design
- Overlay architectural program
- Make the home safe for people (code compliance)
- Control temperature, air, and moisture
- Add ventilation
- Make the envelope air- and weather-tight
- Add continuous insulation to meet the energy goals
- Assess moisture transfer through shell
- Implement robust climate zone-appropriate assemblies
- Reduce energy demand by 2/3 and air-leakage 10X to meet Passive House retrofit standard (EnerPHit)

The Concept

Basement



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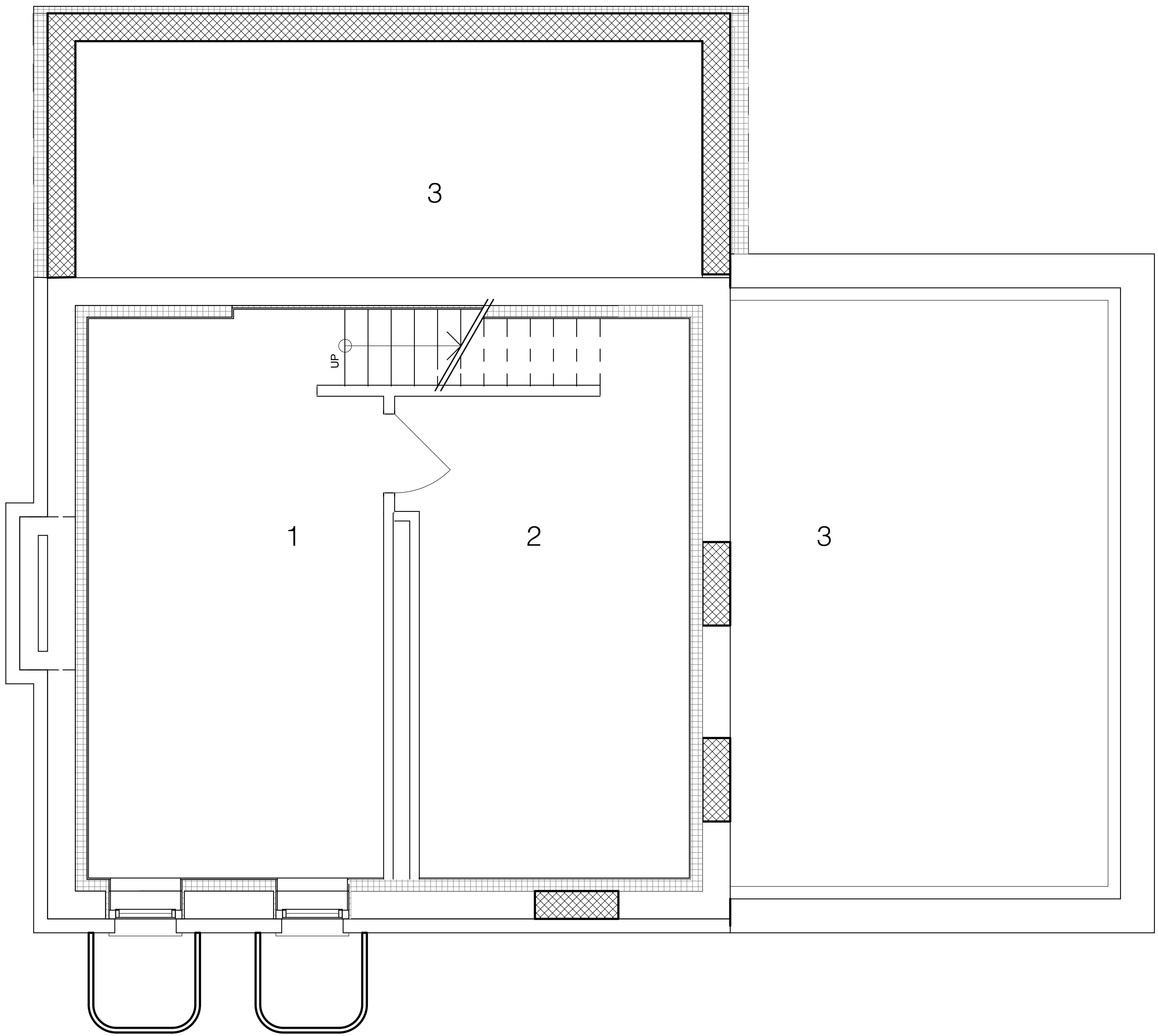
Basement



1. Homeschool Room
2. Mechanical
3. Unexcavated

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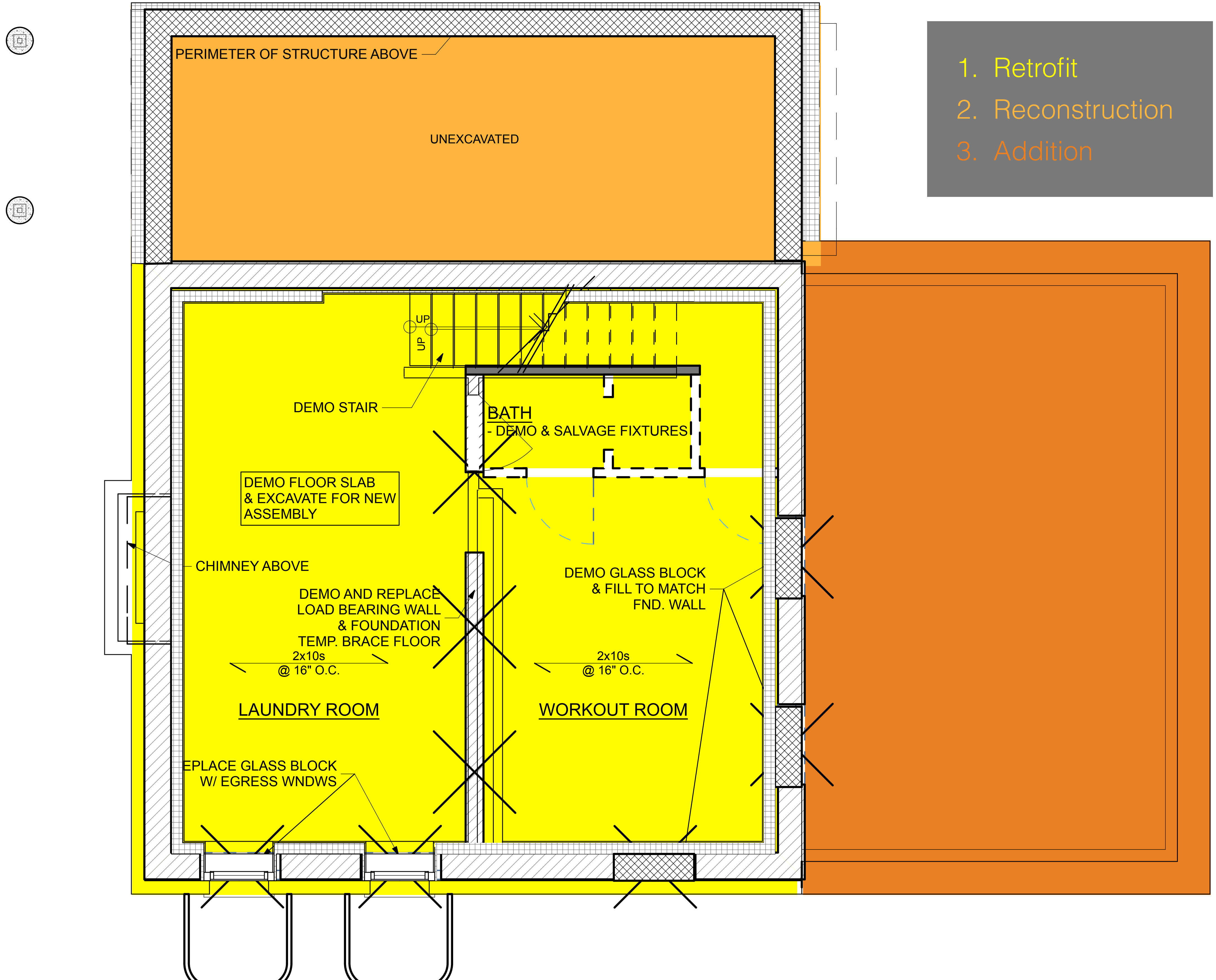
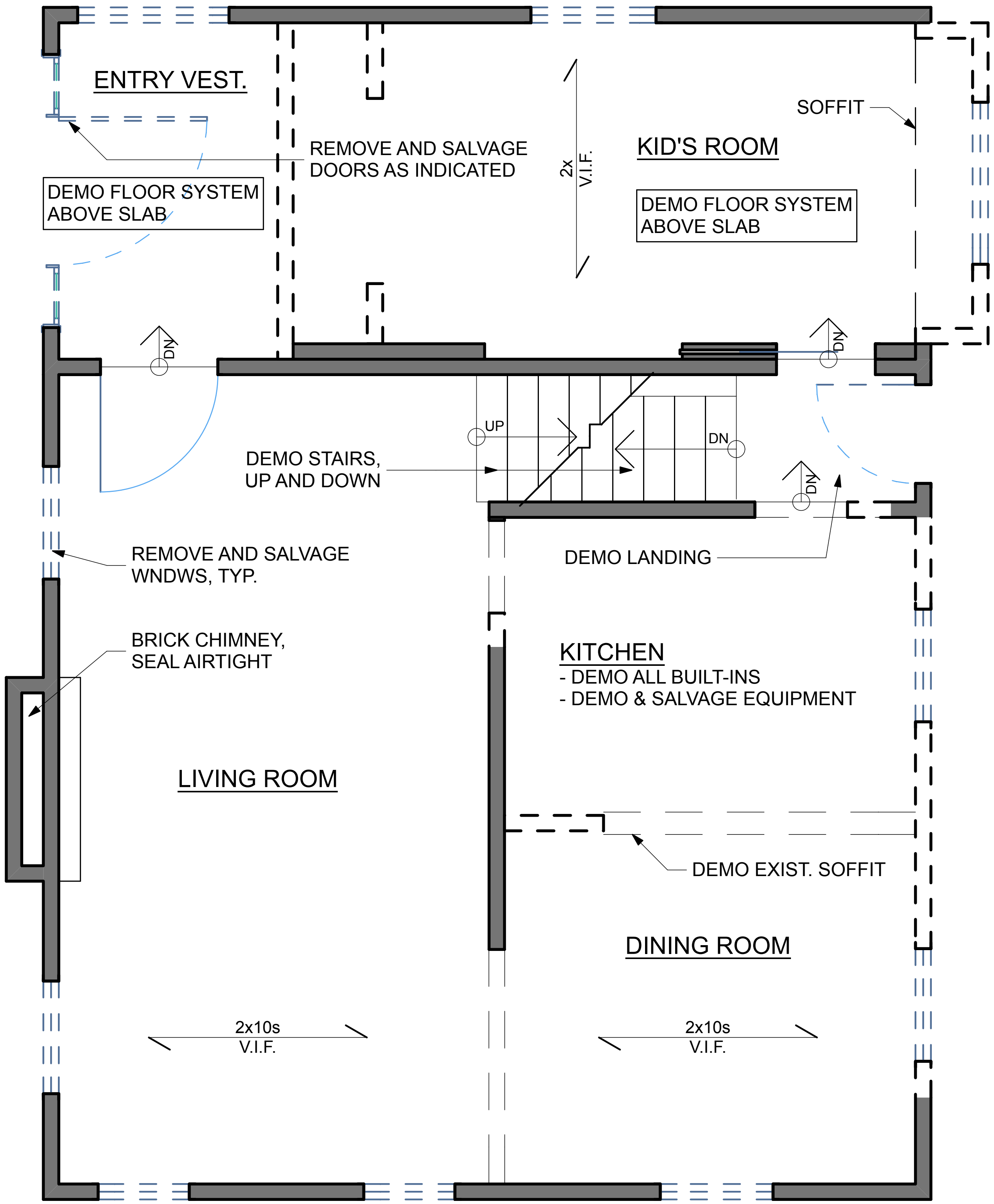
Basement



1. Retrofit
2. Reconstruction
3. Addition

First Floor



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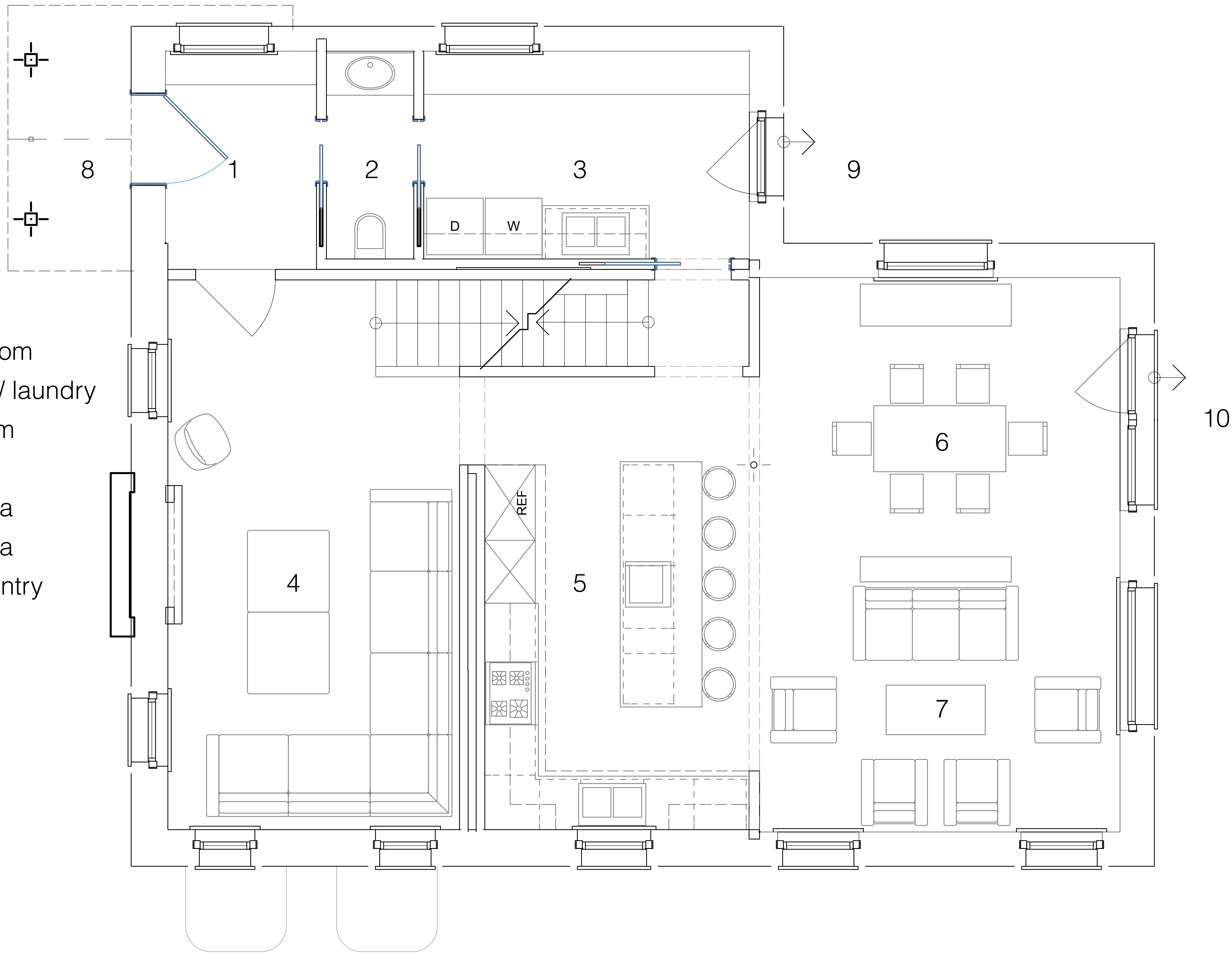
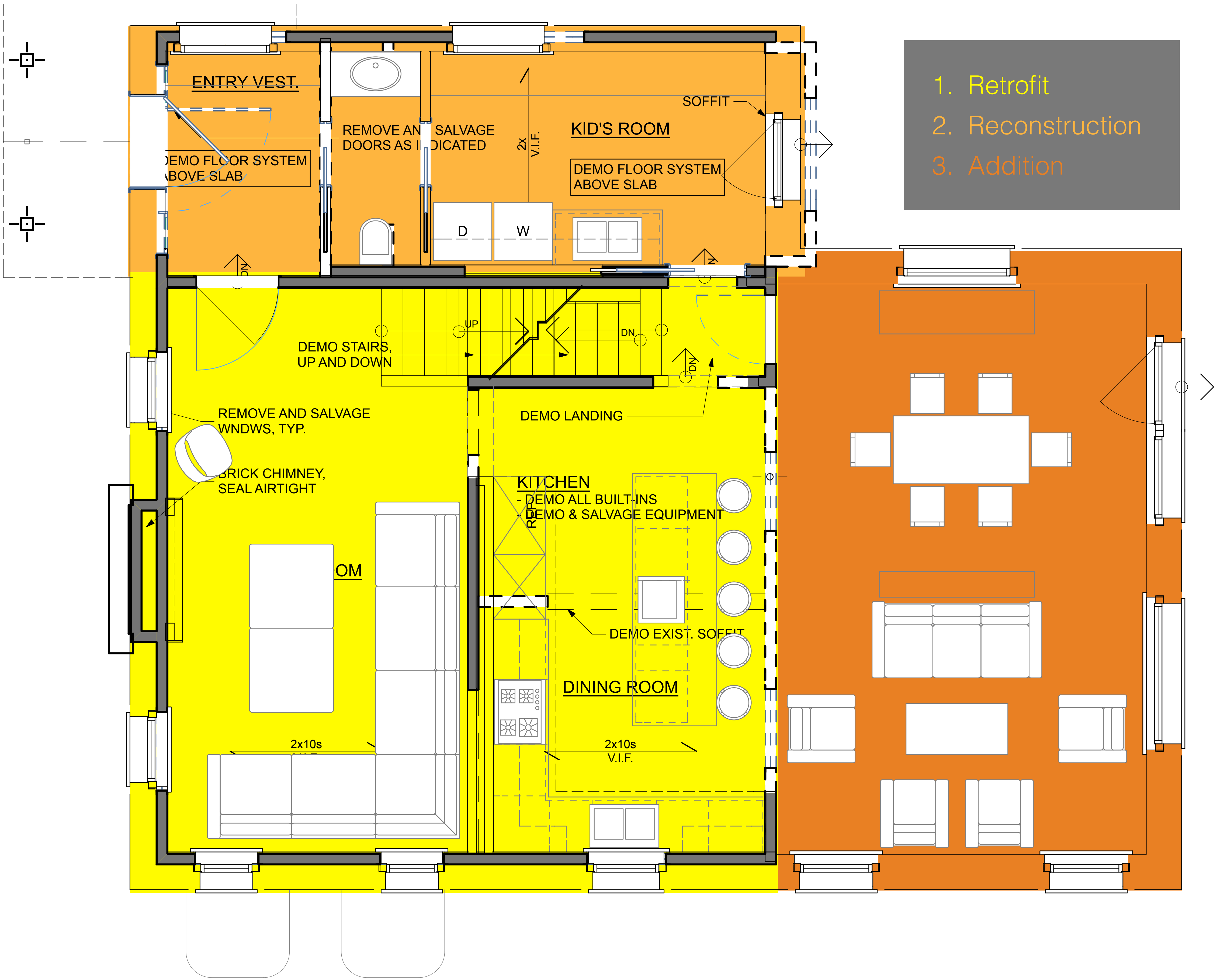
First Floor



1. Entry
2. Powder room
3. Mud room/ laundry
4. Living room
5. Kitchen
6. Dining area
7. Family area
8. Covered entry
9. Rear entry
10. Patio

First Floor



1. Retrofit
2. Reconstruction
3. Addition

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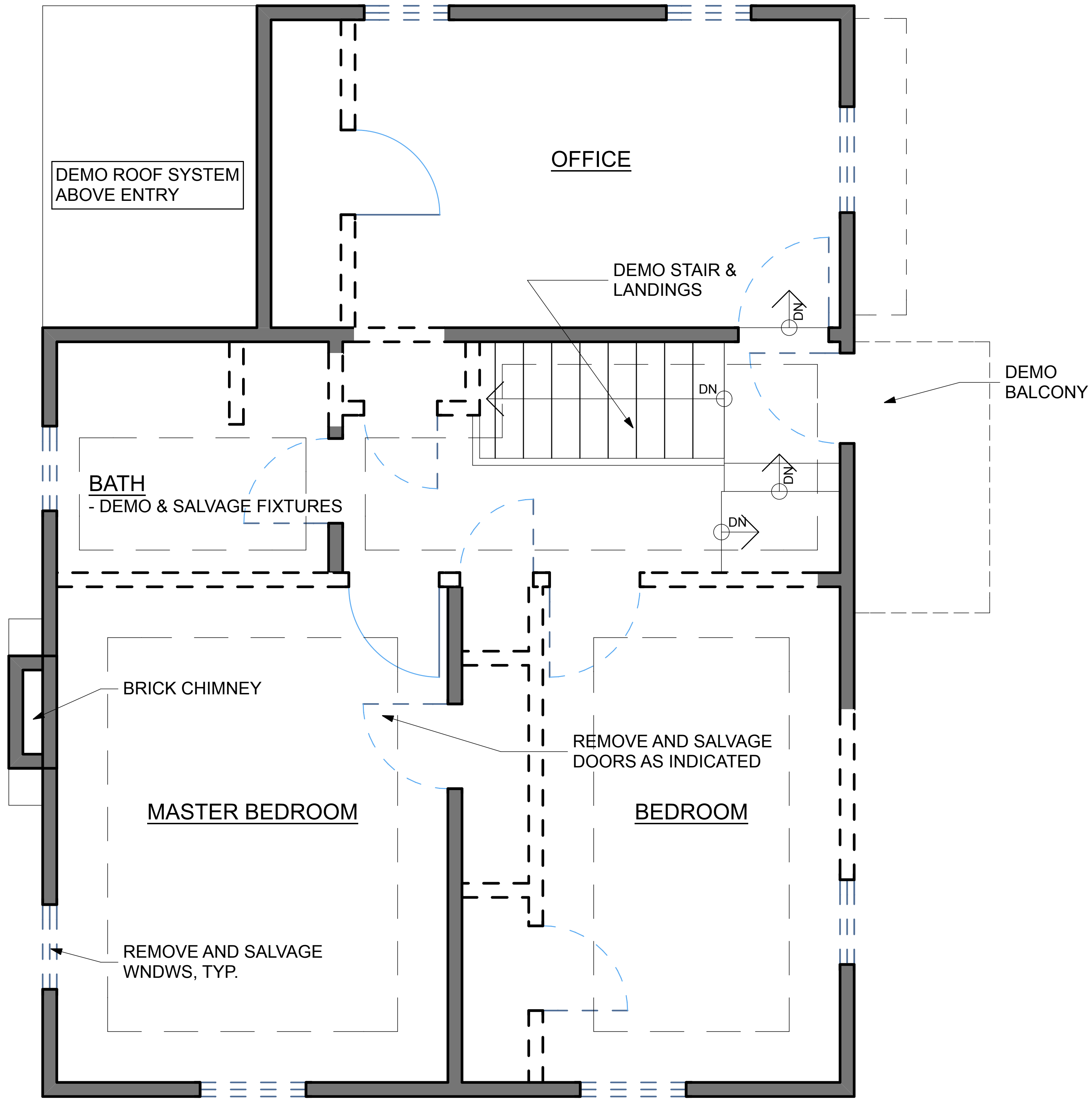
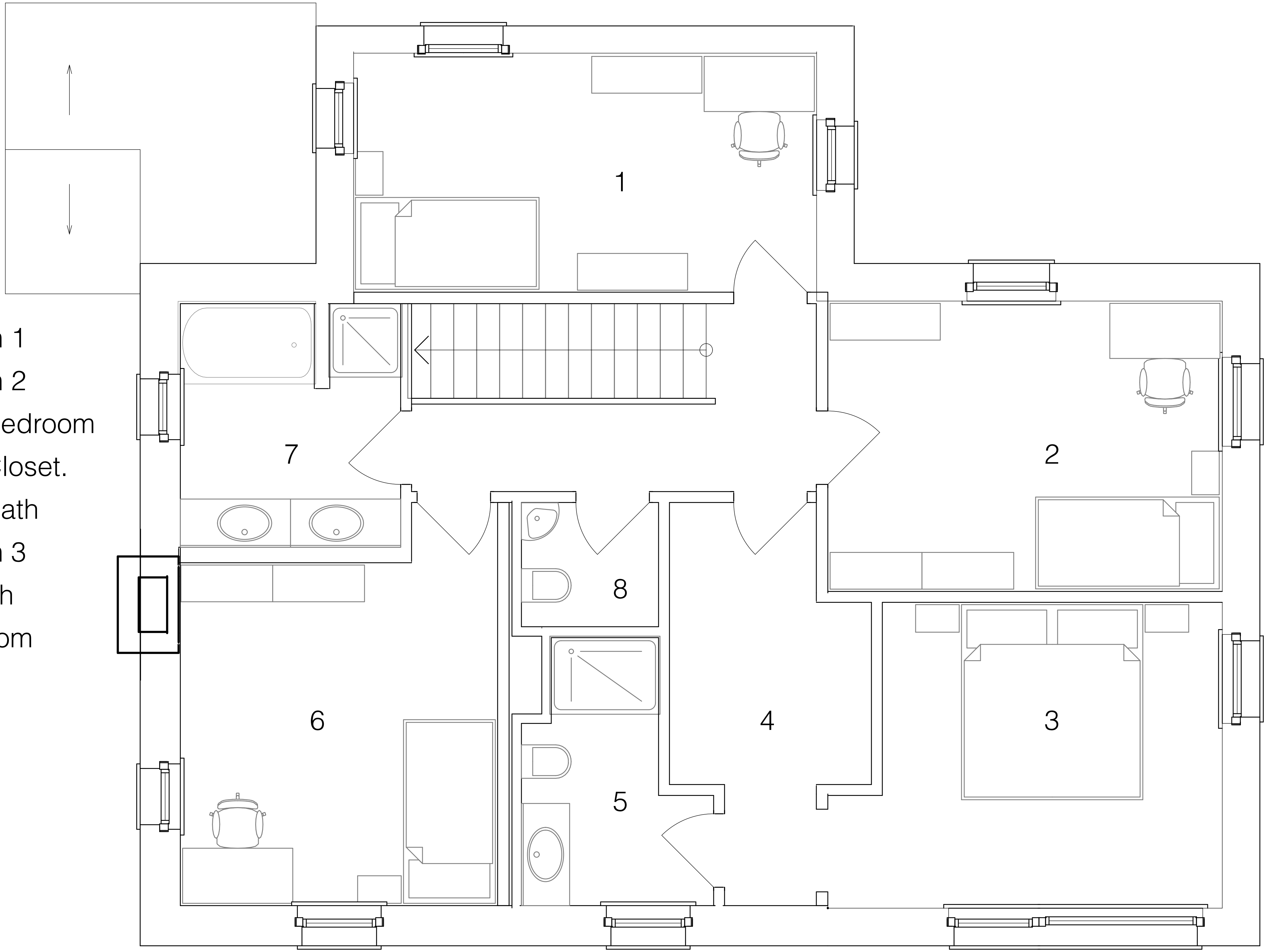
Second Floor

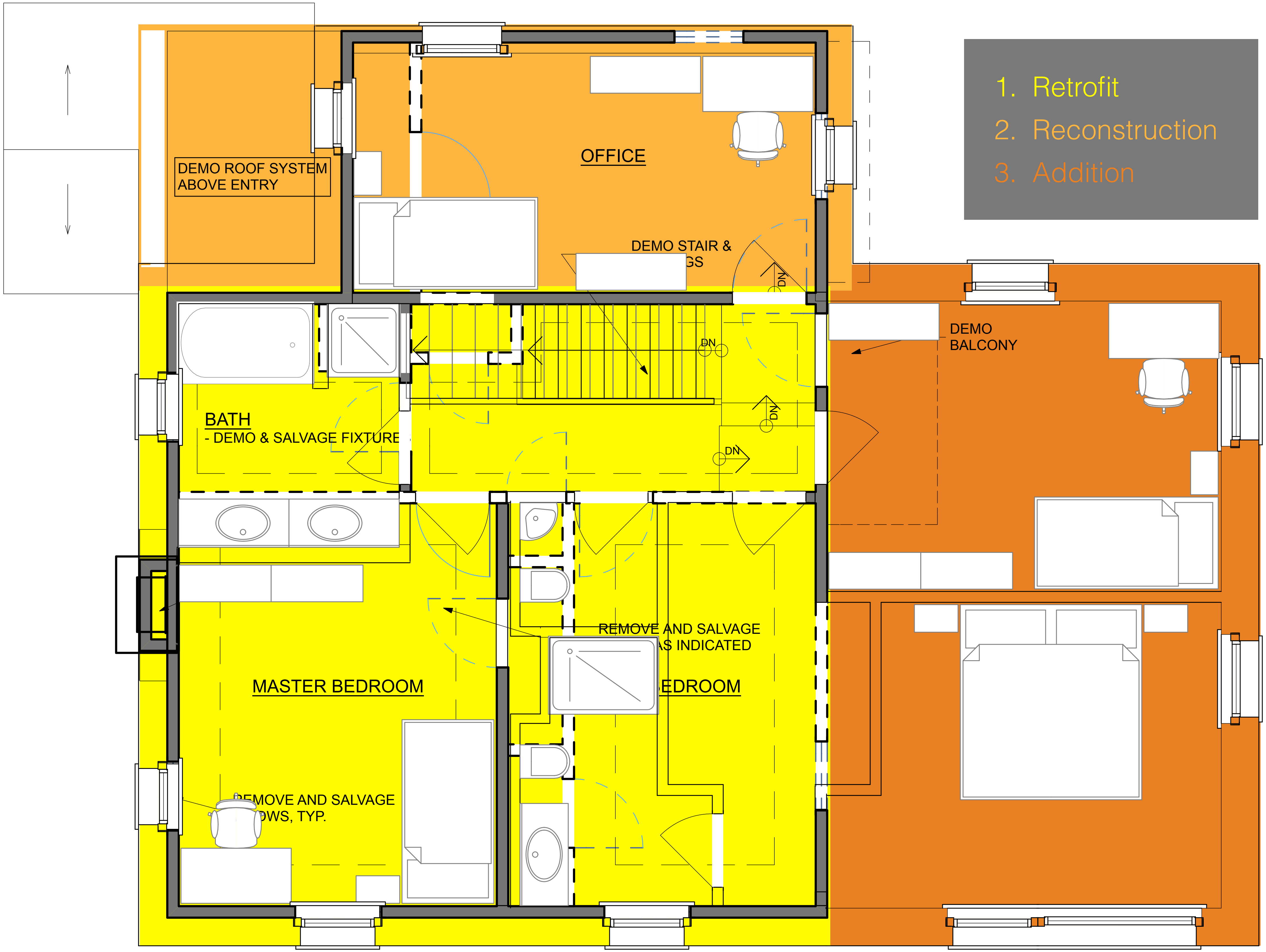


Second Floor



1. Bedroom 1
2. Bedroom 2
3. Master Bedroom
4. Master Closet.
5. Master Bath
6. Bedroom 3
7. Kid's Bath
8. Toilet Room

Second Floor



1. Retrofit
2. Reconstruction
3. Addition

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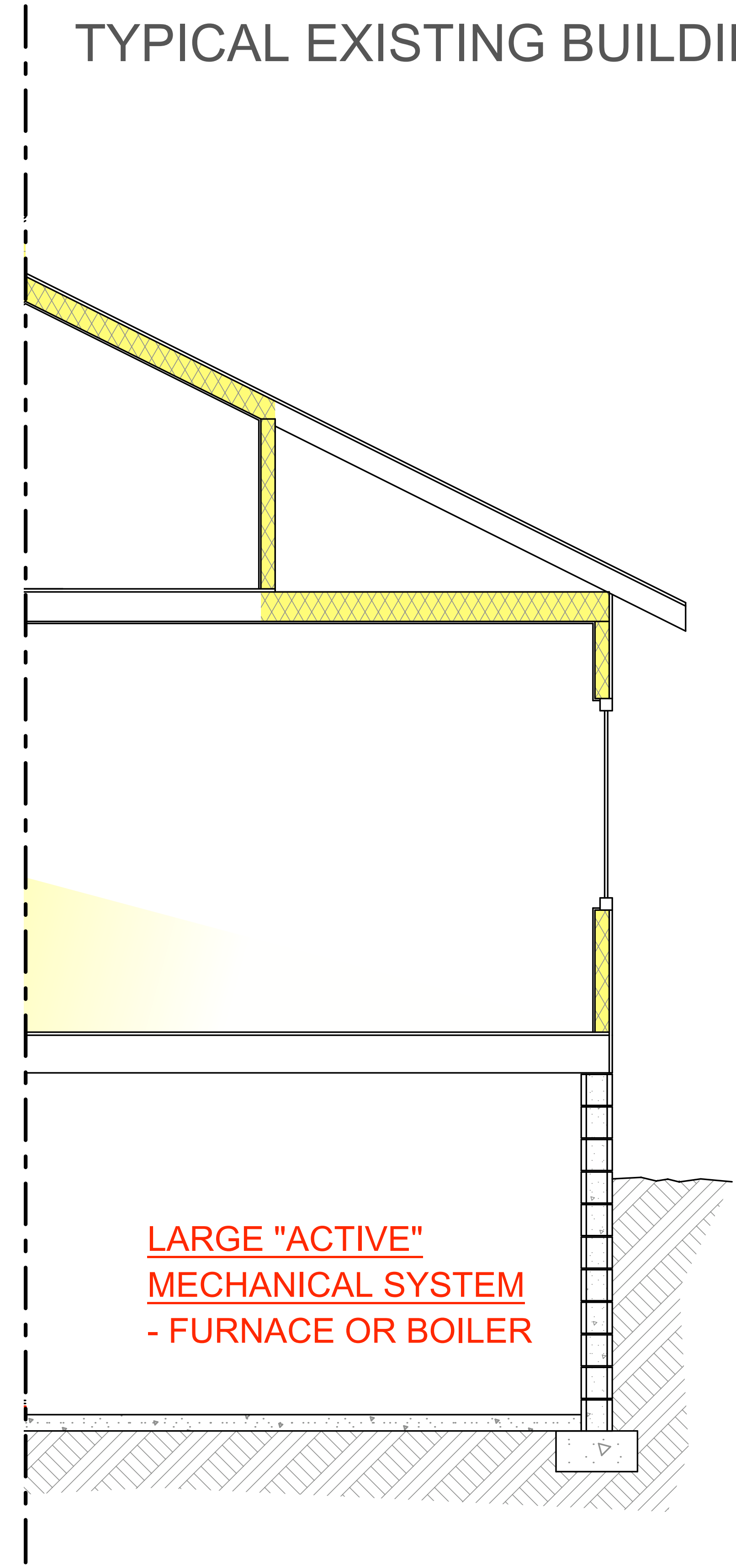
Retrofit Concept

TYPICAL EXISTING BUILDING (BEFORE)



EXISTING CONDITION
- INSUFFICIENT INSULATION
- LOW-PERFORMANCE
  WINDOWS AND DOORS
- AIR LEAKAGE
- NO VENTILATION

EXISTING CONDITION
- NO WATER PROOFING
  AND MANAGEMENT
- NO INSULATION AT AND
  BELOW GRADE
- THERMAL BRIDGES

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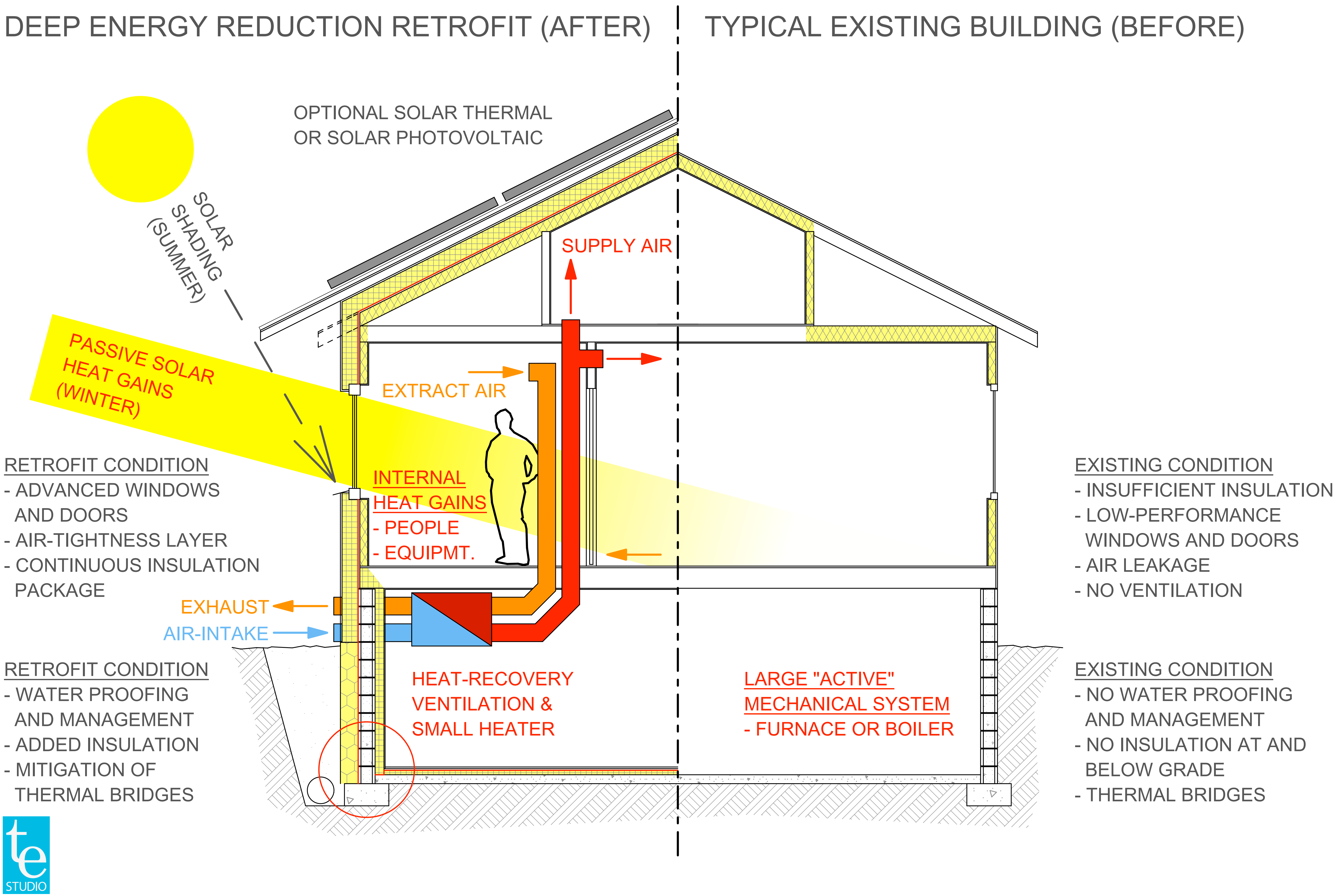
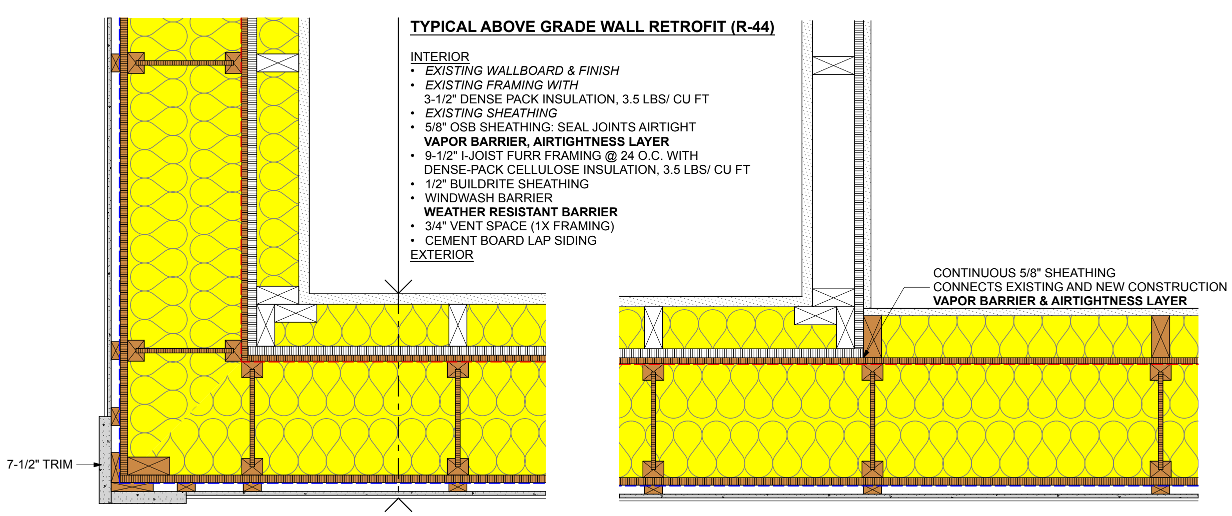
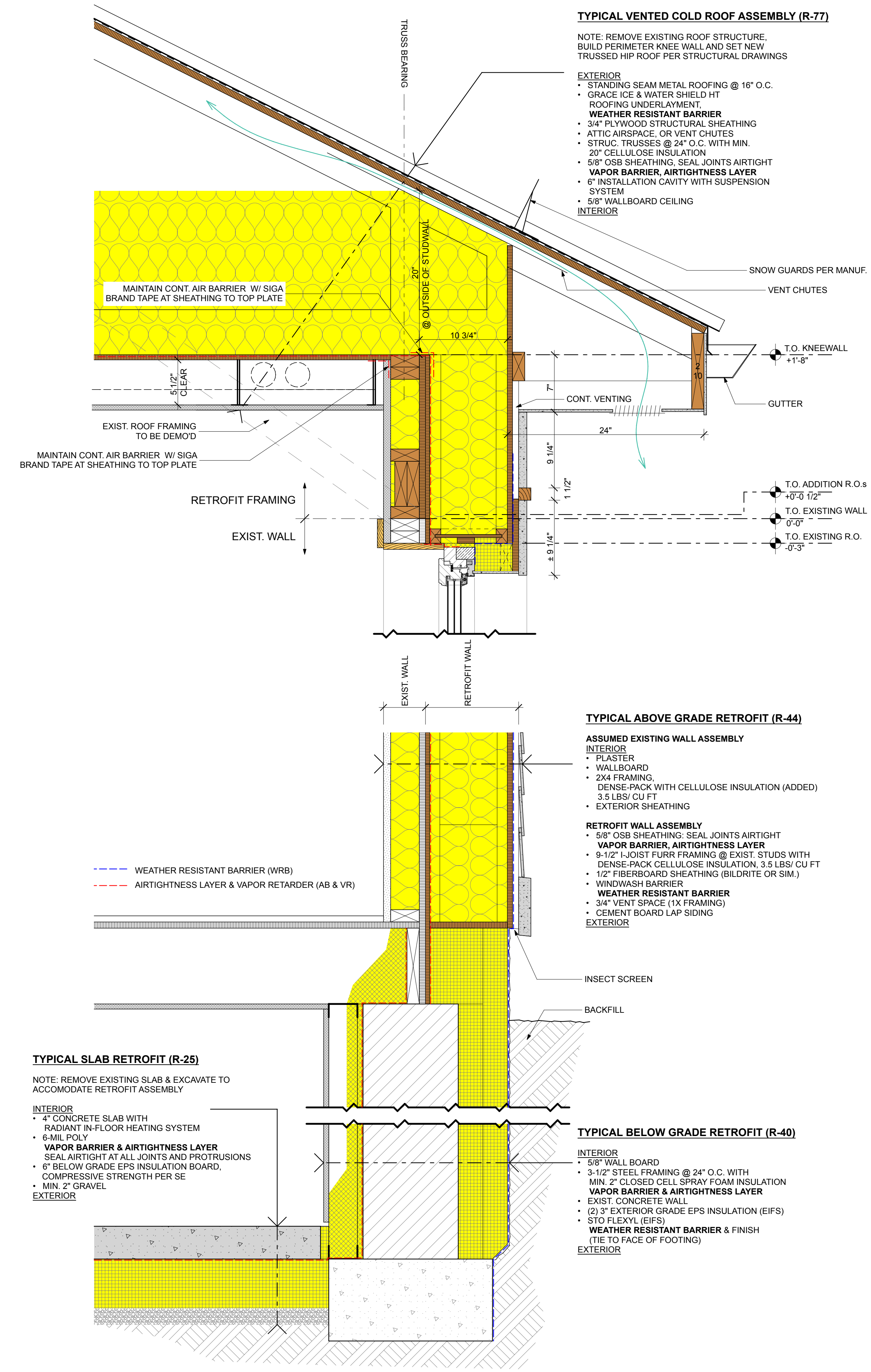
Retrofit Concept



Assemblies

- Walls a/ grade: R-10 to R-44
- Walls b/ grade: R-1 to R-30+
- Roof: R-20 to R-77
- Slab: R-1 to R-25





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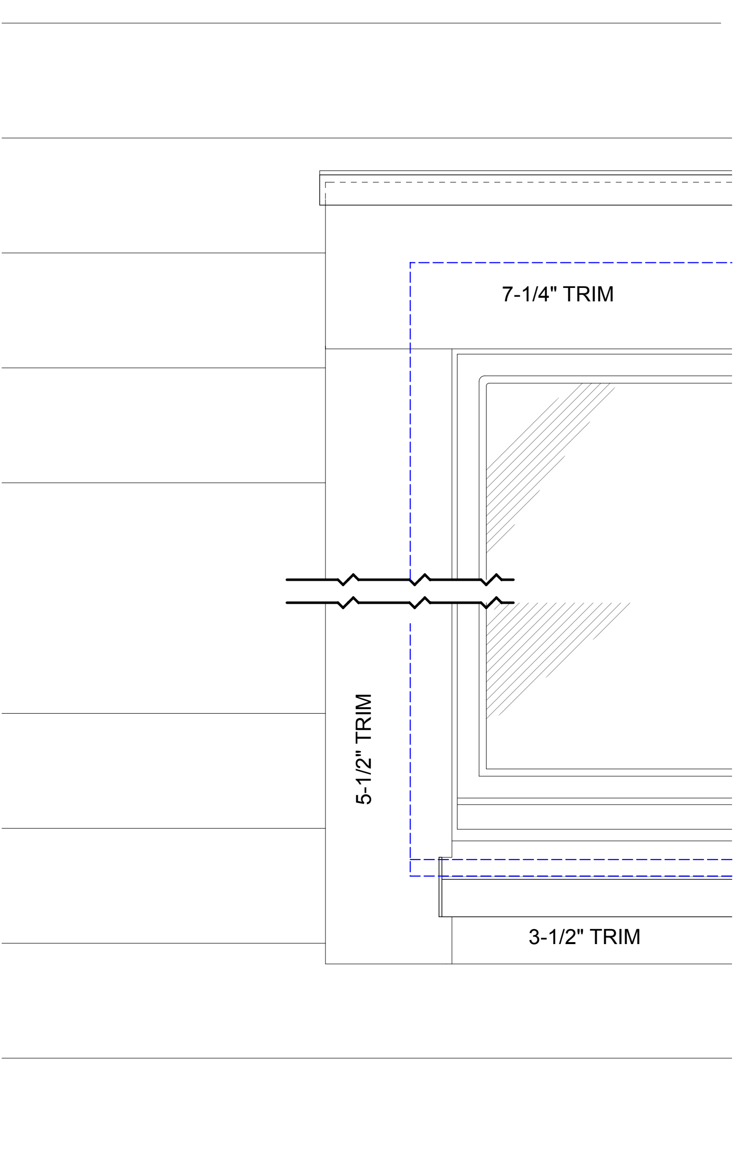
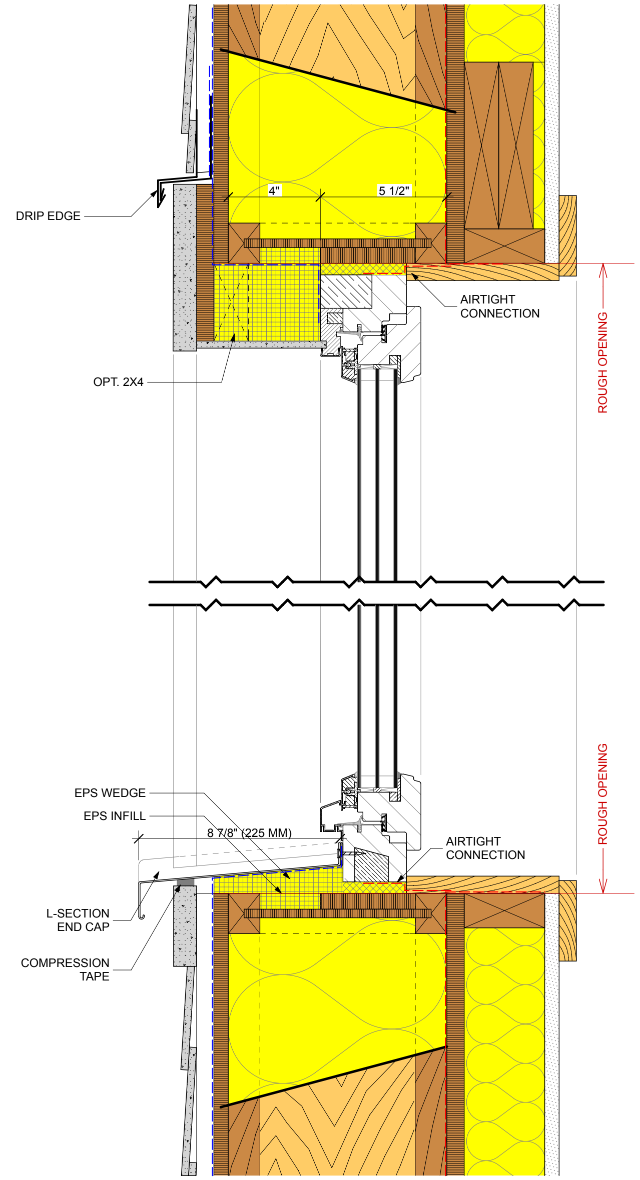
WEATHER RESISTANT BARRIER (WRB)
AIRTIGHTNESS LAYER & VAPOR RETARDER (AB & VR)

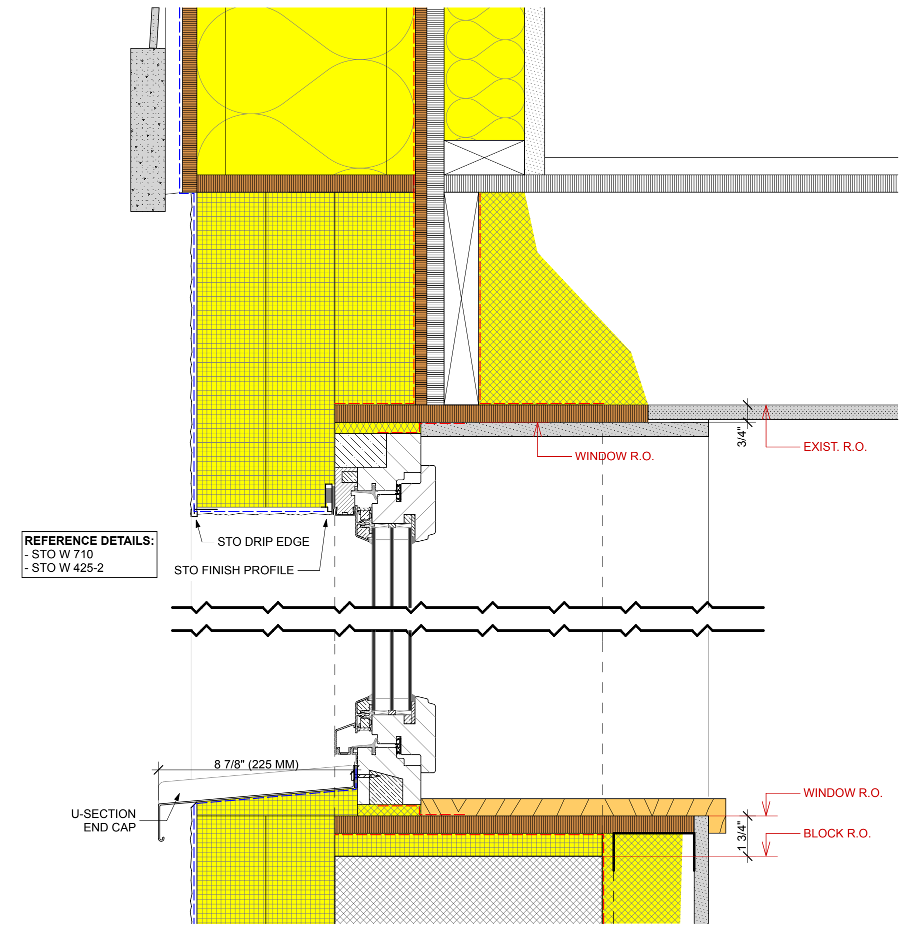
Details



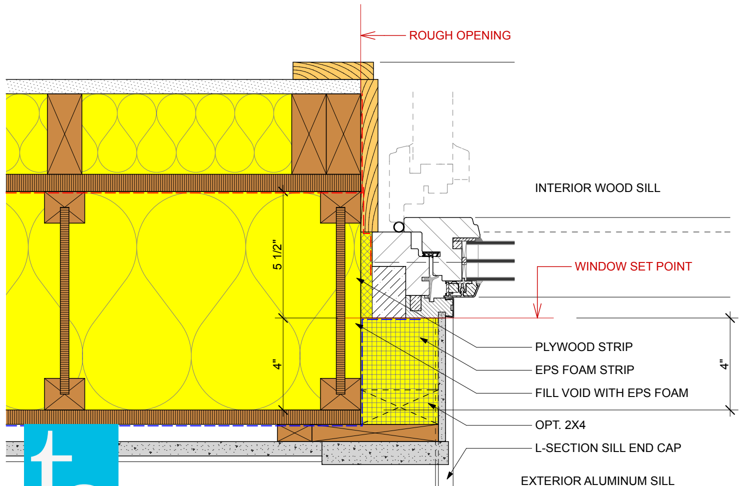
1 TYPICAL EXTERIOR WINDOW ELEVATION
SCALE: 3" = 1'-0"

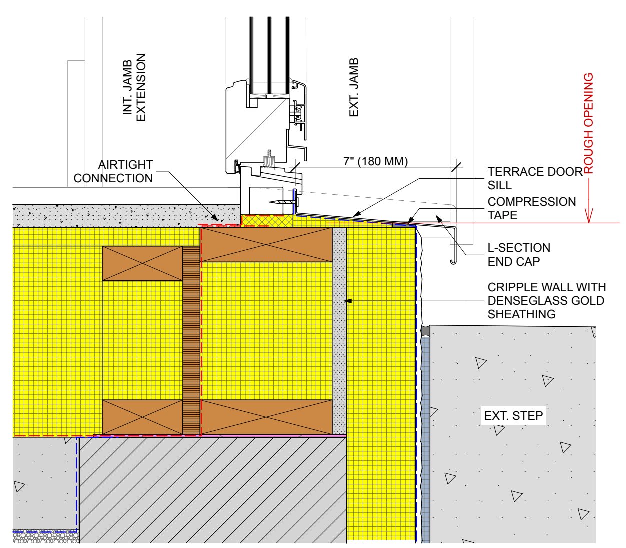


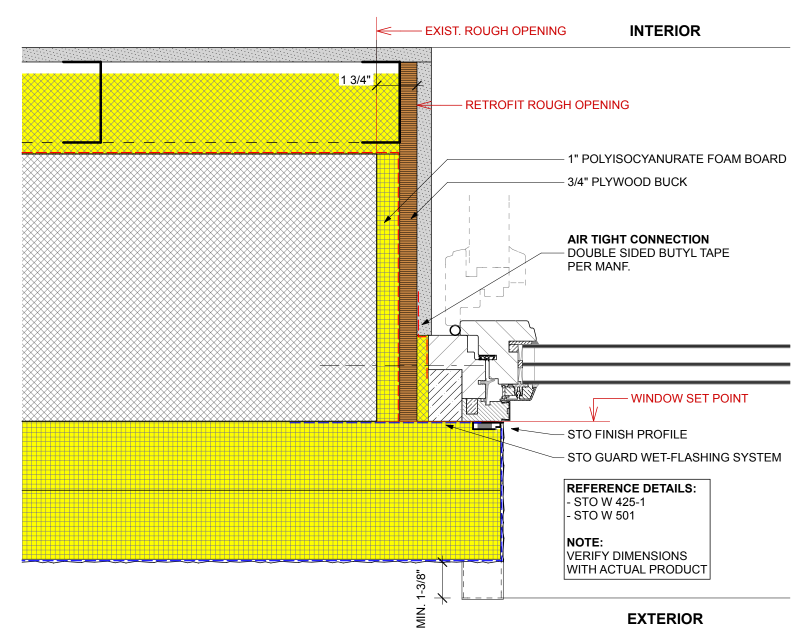
2 TYPICAL WINDOW HEAD & SILL
SCALE: 3" = 1'-0"



5 TYPICAL WINDOW HEAD & SILL, BASEMENT
SCALE: 3" = 1'-0"





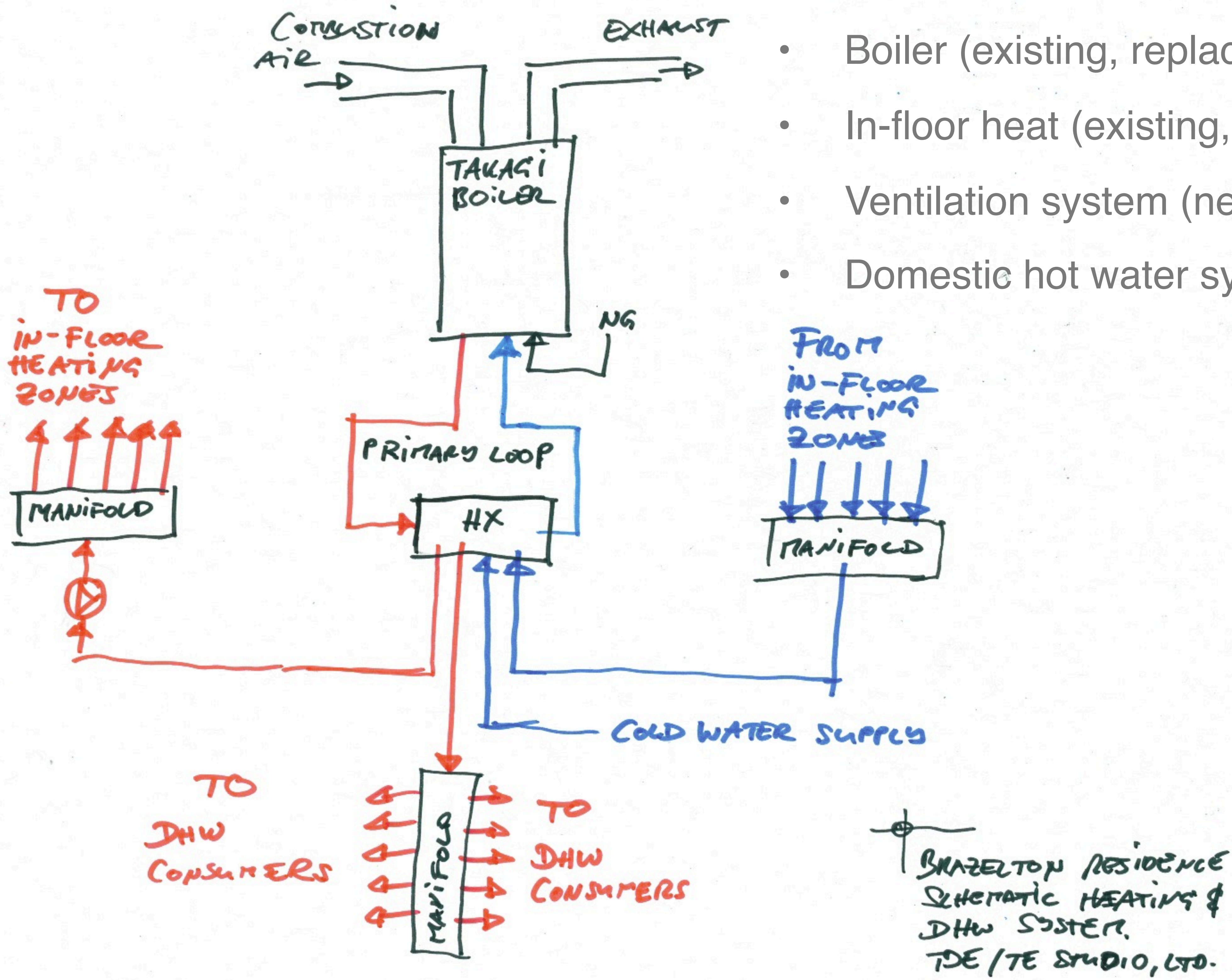


YPICAL WINDOW JAMB
SCALE: 3" = 1'-0"

4 TYP. TERRACE DOOR SILL
SCALE: 3" = 1'-0"

6 TYPICAL WINDOW JAMB, BASEMENT
SCALE: 3" = 1'-0"

MEP Systems



- Boiler (existing, replaced)
- In-floor heat (existing, reused and expanded)
- Ventilation system (new)
- Domestic hot water system (new plumbing)

Construction Project


PC75UU
KOMATSU
VEIT
S208054
S208054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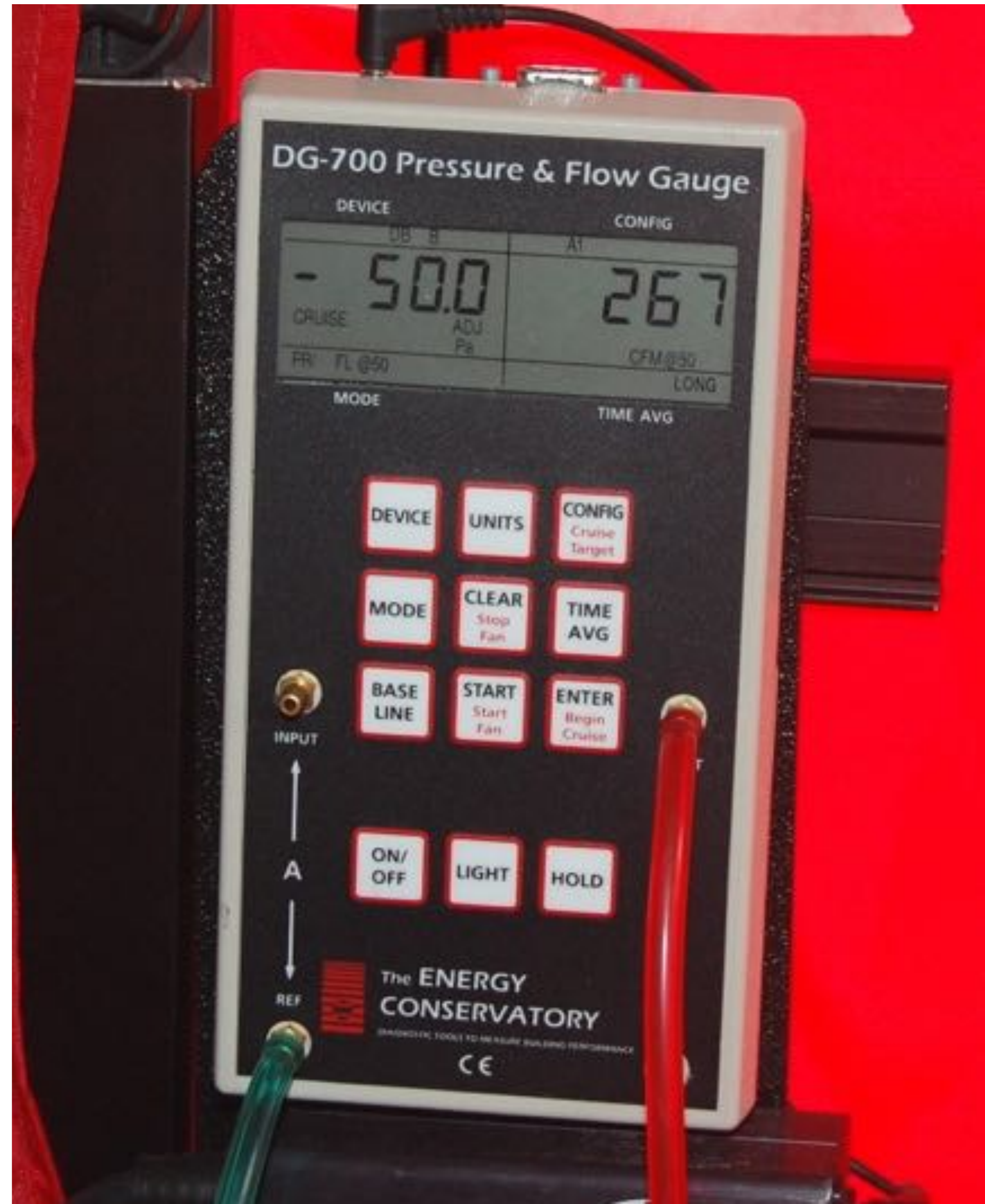
≤1.0

Airtightness

Rough-In Test

0.87 ACH$_{50}$ [267 CFM$_{50}$]




WERNER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Whole House Heat Recovery Ventilation

Insulated Tubes

Home-Run Distribution with Tubes

Installation/Service Cavities

Registers: Plug & Play

Heat Source: On-Demand Boiler (existing)

Unique Feature: Water Tree

Minisplit AC

The Result

Photos: Spaces Magazine


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Photos: Spaces Magazine

Homeowners Paul and Desiree Brazelton whip up a fresh egg breakfast. All their eggs come from a brood of hens cooped in the back yard.

Photos: Spaces Magazine

Photos: Spaces Magazine


Photos: Spaces Magazine


Photos: Spaces Magazine

Penelope, 7, Amelie, 9, and Madeline, 5, jump for joy (with special permission) in the master bedroom.

> **Bedding and curtain,** westelm.com

Photos: Spaces Magazine

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Photos: Spaces Magazine

Photos: Spaces Magazine

Speed racer Madeline is all about pink.

> **Bedding,** target.com
> **Rug and curtain,** ikea.com

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Photos: Spaces Magazine

Certified Performance

≤1.0

Airtightness

Final Test

0.65 ACH_{50} [195 CFM_{50}]

Passive House Performance

Component Approach
Minimum R-values throughout

Heating Load
20 W/m² [6.3 Btu/h/ft²]
4.1 kW [14 kBtu/h]

Cooling Load
2.6 kW
[0.74 tons, 8.8 kBtu/h]

Airtightness
0.65 ACH_{50} [196 CFM_{50}]

≤1.0

Specific Primary Energy Demand
112 kWh/m² a [35.5 kBTU/ft² a]

≤130

QP ≤ 120 kWh/m²a + ((QH - 15 kWh/(m²a)) * 1.2)

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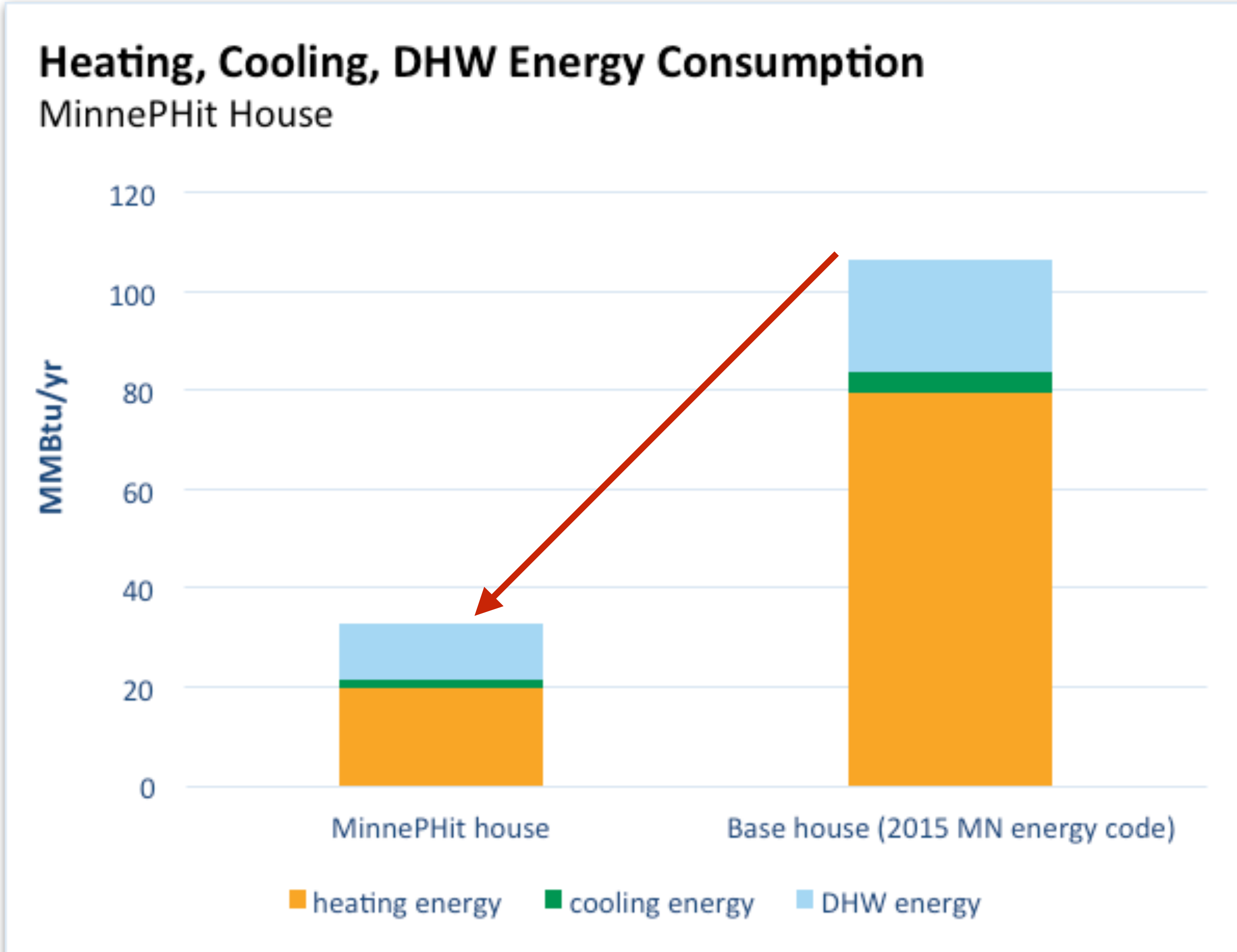
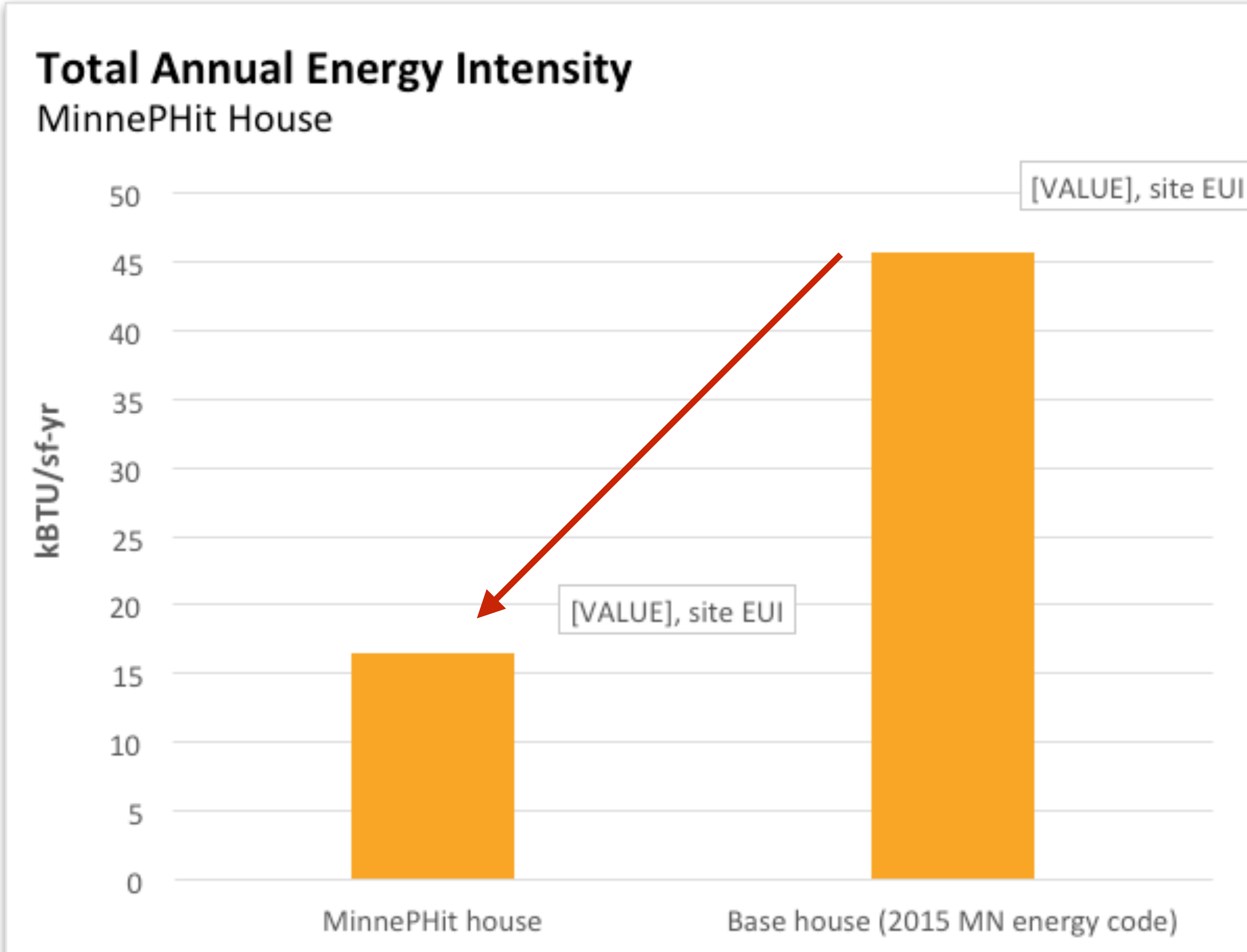
Passive House Comparison



Heat loss is dramatically reduced by more than 66% over current new construction in Minnesota.

Passive House Comparison



Annual energy intensity was calculated at 16.5 kBTU/(sf yr).

This is a savings of 64% compared to a similarly-sized house meeting MN 2015 residential energy code—modeled at 45.7 kBTU/(sf yr).

Passive House Certification

Certificate

Certificate ID: 5583_PHI_EP-Pilot_20130110_STh

Passive House Institute
Dr. Wolfgang Feist
Rheinstraße 44/46
64283 Darmstadt, Germany

PHI

The Passive House Institute hereby awards the EnerPHit Pilot Project certificate to the following building:

EnerPHit Pilot Project in Minneapolis, 5605 Bloomington Avenue S., MN 55417 Minneapolis, USA

EnerPHit ✓
Pilot Project
Passive House Institute

Client:	Paul&Desiree Brazelton 5605 Bloomington Avenue S., MN 55417 Minneapolis, USA
Architecture:	Tim Eian - TE Studio, Ltd. 212 2nd St.SE #222, MN 55414 Minneapolis, USA
Building Services:	TE Studio, Zehnder USA, Paul Brazelton

This building was designed to meet the Passive House component energy retrofit criteria as defined by the Passive House Institute Darmstadt. Given appropriate on-site implementation, this building has the following characteristics:

Building characteristics:	Achieved		Required	
Annual specific space heating demand	27 kWh/(m²a)	=	25 kWh/(m²a)	-[1]
Annual specific primary energy demand[2] for heating, DHW, ventilation and all other electric appliances for standard use	120 kWh/(m²a)	=	134 kWh/(m²a)	✓
Airtightness of building envelope n_{50} as per test result	0.7 h^{-1}	=	1.0 h^{-1}	✓
Mean value of individual building component thermal protection :				
Exterior insulation to ambient Thermal transmittance (U-value)	0.11 W/(m²K)			✓
Exterior insulation to ground Thermal transmittance (U-value)	0.17 W/(m²K)			-
Interior insulation to ground Thermal transmittance (U-value)	0.17 W/(m²K)			✓
Thermal bridges Δ_U Building envelope (window installation excluded)	0.01 W/(m²K)		No limiting value	
Windows Thermal transmittance $U_{w,installed}$	0.77 W/(m²K)			✓[2]
Exterior doors Thermal transmittance $U_{w,installed}$	0.79 W/(m²K)			✓
Ventilation unit Effective efficiency of heat recovery	89 %			✓

[1]Limiting value is not relevant. [2]Improved windows ($U_{w,\ installed}$ = 0.65 W/(m²K)) are recommended in order to meet comfort criteria in winter conditions as optimal thermal comfort directly near window areas cannot currently be guaranteed. Thick curtains or use of floor heating is thus recommended.

Certification criteria met? Selection of the evalulation method		
	Space heating demand	
	Component quality	✓

issued:
Darmstadt, 10.01.2013

Wolfgang Feist
Dr. Wolfgang Feist

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Mission Accomplished!

- Structure ✓
- Weather Barrier ✓
- Insulation ✓
- Airtightness ✓
- Moisture Management ✓
- Ventilation/ Air Quality ✓
- Comfort ✓
- Daylight ✓
- Durability (50-100 years) ✓
- Design ✓
- Lifecycle Cost ✓
- Environmental Impact ✓
- Deconstructability ✓

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HOLISTIC DESIGN

Resources

EnerPHit

Quality-Approved
Energy Retrofit with
Passive House Components
Dr. Wolfgang Feist

PHI **Low Energy** Building

passivehouse.com

passipedia.org

passivehouse-international.org

Thank you!

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