Passivhaus (pas′iv-həus)

Passive House

in a very cold climate zone

ENERGY DESIGN conference & expo

workshops • seminars • product exhibits

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** continuing education requirements."

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

www.passivehouse.com

Tim
Eian

te STUDIO

high performance architecture

intep

Building Performance, Measured Results

Learning Objectives

1. Performance by design
    1.1. Cost
    1.2. Siting
    1.3. Very cold climate design considerations
    1.4. Leveraging an integrated team approach to make Passive House happen
2. Performance by engineering
    2.1. Dialing in performance with the PHPP
    2.2. Pragmatic considerations
    2.3. Life cycle cost vs. first day cost
3. Passive House basics in action
    3.1. Super-insulated assemblies
    3.2. Airtight construction
    3.3. Passive House windows
    3.4. Avoidance of thermal bridging
    3.5. Balanced heat recovery ventilation and a little heating/cooling
4. Passive House resources

“Passivhaus” - Passive House

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

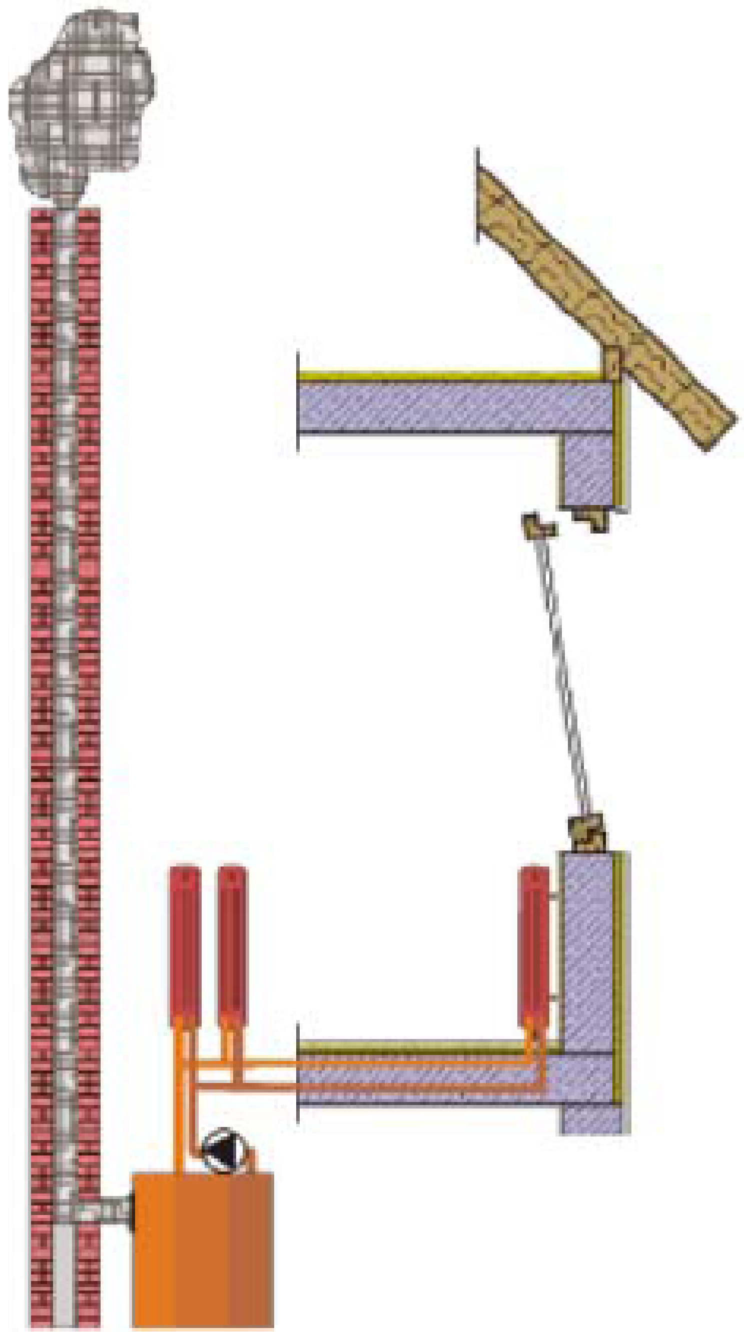
Passive House in 90 Seconds

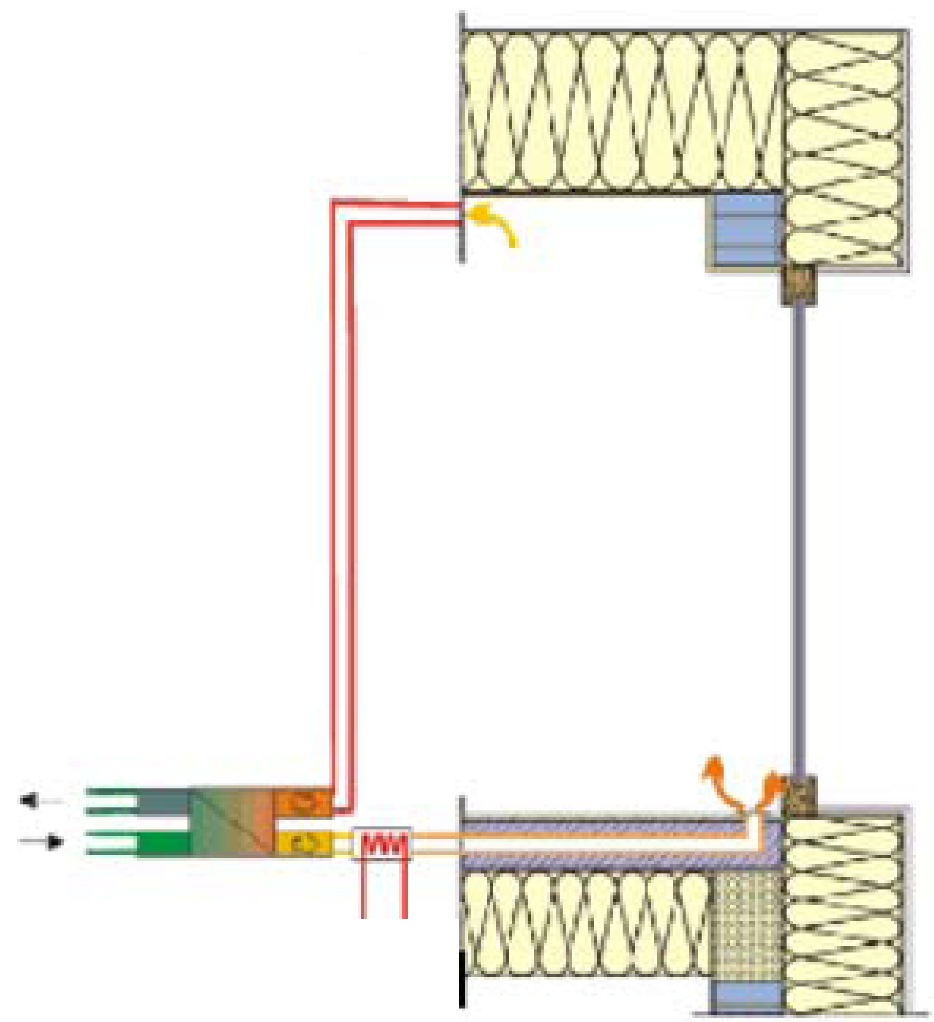
Video: Hans-Jörn Eich

Basic Concept

- Conservation first
- Minimize losses
- Maximize (free) gains

Active versus Passive





Active: 25-125 kBtu/(sf yr)

85 - 450 kWh/(m² a), typically found in the U.S.

Passive: 4.75 kBtu/(sf yr)

15kWh/(m² a), maximum target

Source: Krapmeier & Drössler 2001

Third-Party Certified

te STUDIO intep

Tool for Sustainable Design

Metrics

Energy per Square Foot and Year

Gas mileage for buildings.

Heating/ Cooling Energy Targets

PHI Low Energy Building

Entry Level

≤ 9.5 kBtu/(sf yr)

≤ 30kWh/(m^2 a)

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

Retrofit

≤ 7.9 kBtu/(sf yr)

≤ 25kWh/(m^2 a)

New Construction

≤ 4.75 kBtu/(sf yr)

≤ 15kWh/(m^2 a)

Alternative Target for Heating/ Cooling Load

≤ 3.17 Btu/(h sf)

≤ 10W/m^2

Airtightness Target

$\leq 0.6\ ACH_{50}$

PHI Low Energy Building

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

$\leq 1.0\ ACH_{50}$

Measured with a blower door in the field.

Image source: TE Studio

Source Energy Targets

PHI Low Energy Building

$\leq$ 38 kBtu/(sf yr)

$\leq$ 120kWh/(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)

How to set up a cold-climate
Passive House for success

Performance by Design

Passive House Paradigm Shift

Reliance on ACTIVE systems

Status quo

Image source: Utahfirearmclassifieds.com

Resilience through PASSIVE systems

Airtight

Super-insulated

Balanced, heat-recovery ventilation

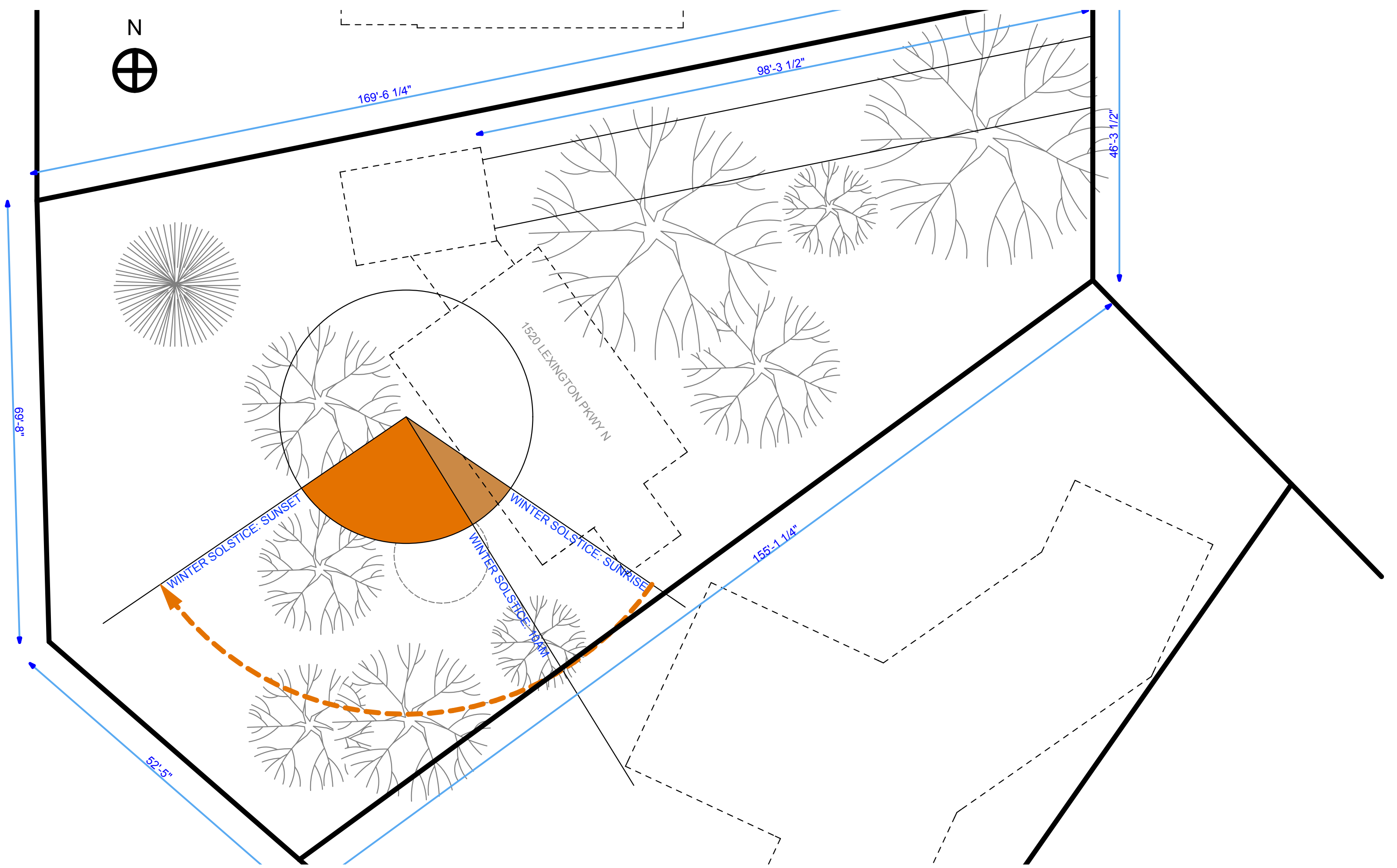
=

(Heat it with a candle!)

Cost

The “cheapest” Passive House project is one that is designed from the outset to become a Passive House building. It is therefore imperative to utilize and follow the Passive House design parameters from day one in design, planning, and for the construction process, which also includes training for all Project Team Members.

Siting



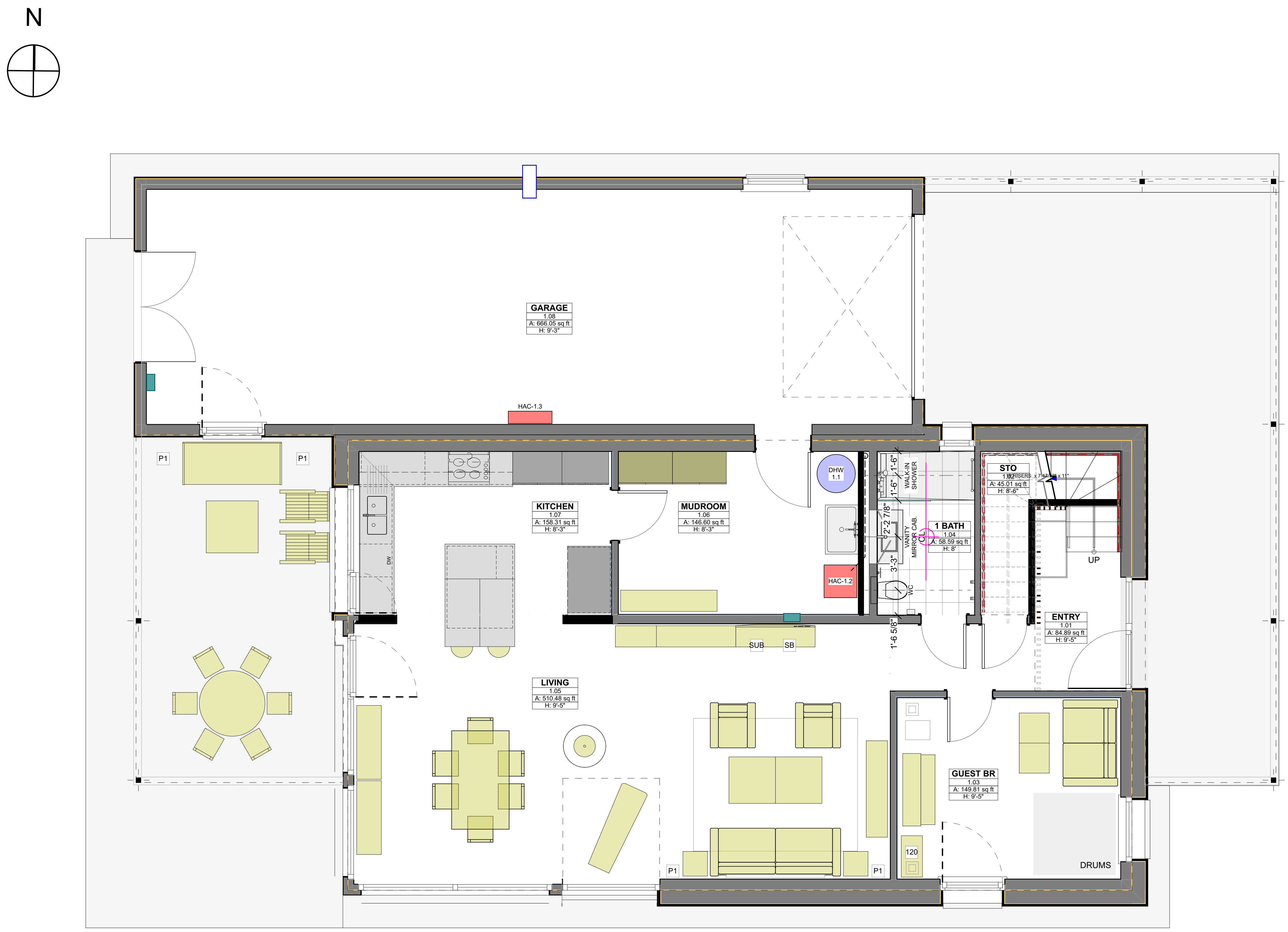
1. Topography
2. Solar window of opportunity
3. Shade objects
4. Views out vs. privacy in vs. solar heat gains
5. Overlay all criteria and balance them


Balance

Very Cold Climate Considerations

The Sun is everything*

*for small buildings

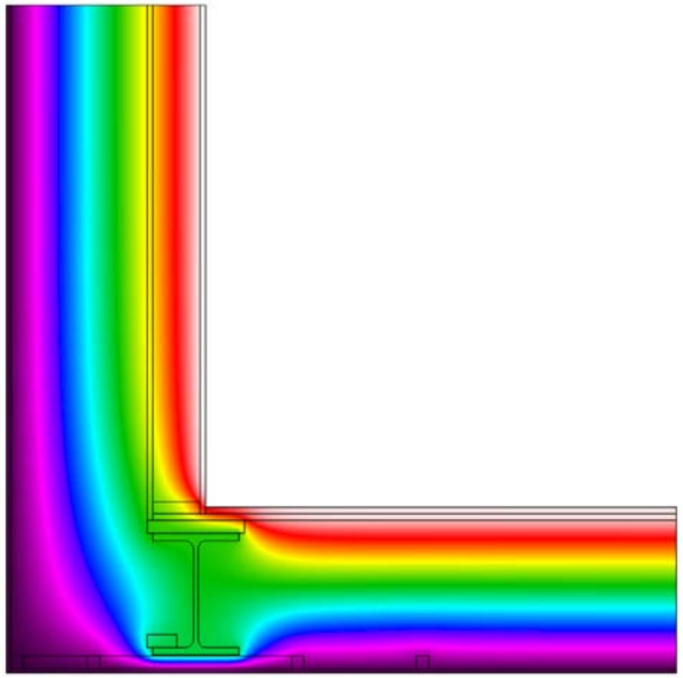


Orient it well and keep it compact!

Thermal Bridges - TE-Studio

CALCULATION OF PSI-VALUES OF TE-STUDIO STANDARD DETAILS

01/08/2014



Results

U-value wall	0.068 W/(m²K)
Length wall	2.000 m
U-value floor	0.083 W/(m²K)
Length floor	2.000 m
Boundary condition outside	0 °C / 0.04 (m²K)/W
Boundary condition wall	20 °C / 0.13 (m²K)/W
Boundary condition floor	20 °C / 0.17 (m²K)/W
ΔT	20 K
Total heat flow / m length	6.536 W/m
Ψ (Psi-value)	**0.025 W/(mK)**

Make a thermal bridge-free design!

Craft it meticulously!

Go Team!

1. Don't just sit at the same table, work together
2. Listen to each other's concerns and ideas but lead with knowledge, experience and confidence
3. Each team member has to live up to the highest expectations
4. Provide a complete delivery of services = no cutting and profit grabbing here

How to set up a cold-climate
Passive House for success

Performance by Engineering

Learn and use the PHPP!

Image source: Passive House Institute

Climate-based

Climate data

Passive House with PHPP Version 9.6a

/ Climate: Minneapolis / TFA: 0 m² / Freq. overheating: % / PER: kWh/(m²a)

Selection of climate data

Country: US-United States of America
Region: Minnesota
1-Sortierung: Alphabetisch
Climate data set: US0040a-Minneapolis
Climate zone: 2: Cold

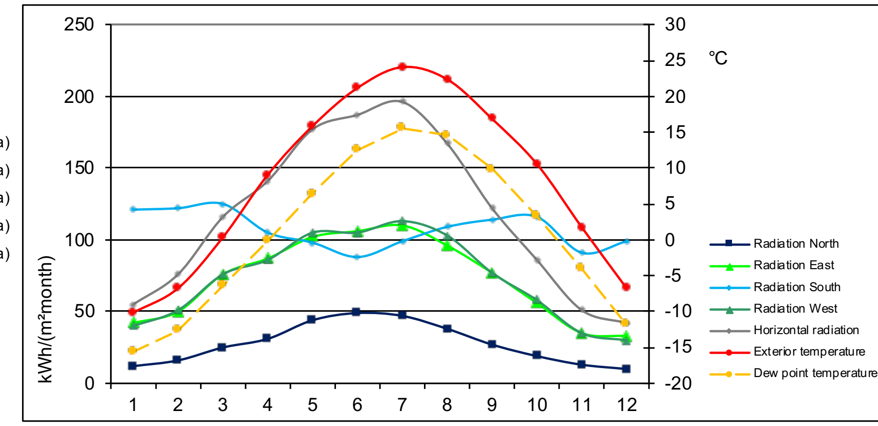
Altitude

Weather station: 276.0 m
Building location: 50 m

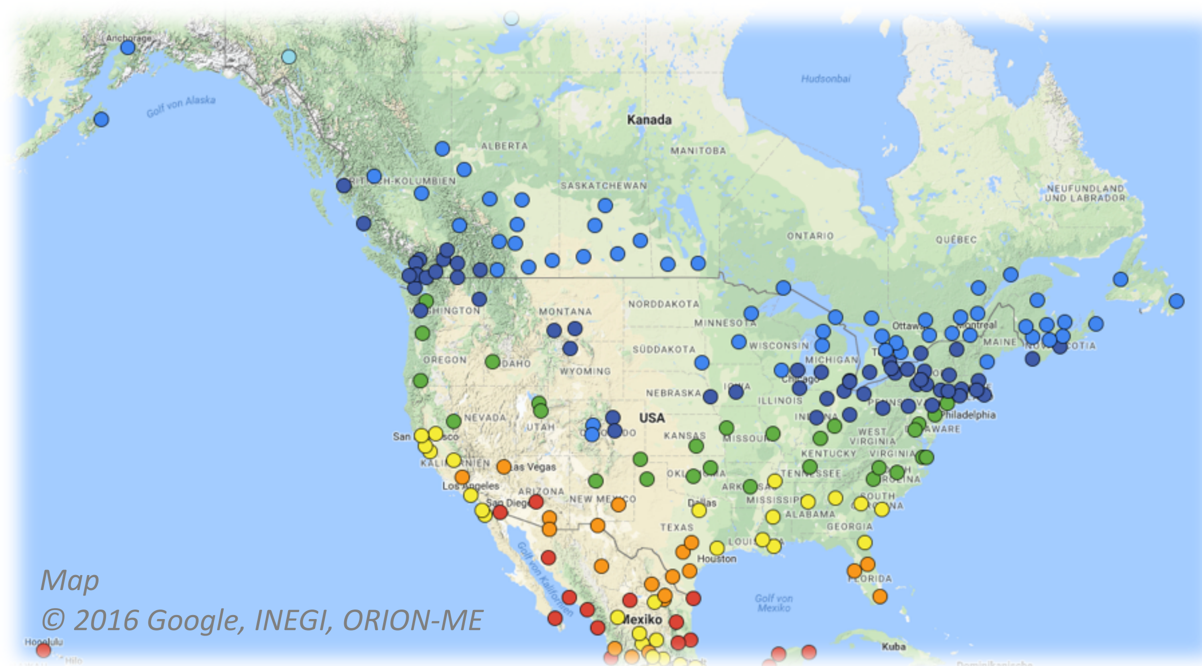
Result overview

Annual heating demand		kWh/(m²a)
Heating load		W/m²
Frequency of overheating		%
Sensible cooling		kWh/(m²a)
Latent cooling		kWh/(m²a)
Cooling load	-	W/m²
PER demand		kWh/(m²a)

	Data for heating Annual method	Data from monthly balance Heating	Cooling	
Heating / cooling period	198	0	0	d/a
Heating / cooling degree hours	101			kKh/a
Radiation North	112	0	0	kWh/(m²a)
Radiation East	336	0	0	kWh/(m²a)
Radiation South	704	0	0	kWh/(m²a)
Radiation West	333	0	0	kWh/(m²a)
Horizontal radiation	501	0	0	kWh/(m²a)



	Month	1	2	3	4	5	6	7	8	9	10	11	12	Heating load		Cooling load		PER	
	Days	31	28	31	30	31	30	31	31	30	31	30	31	Weather 1	Weather 2	Weather 1	Weather 2	factors	
	US0040a-Minneapolis	Latitude °	45.0	Longitude °	-93.3	Altitude [m]	276	Daily temperature swing Summer [K]			11.1			Radiation: [W/m²]		Radiation: [W/m²]			
° C	Exterior temperature	-10.1	-6.7	0.4	9.1	15.9	21.2	24.1	22.4	16.9	10.6	1.8	-6.7	-24.4	-20.9	32.4	32.4	1.20	Household electric
kWh/(m²month)	Radiation North	12	16	25	31	44	49	47	38	27	19	13	10	25	20	100	100	1.20	Domestic hot wate
kWh/(m²month)	Radiation East	42	50	76	87	102	106	110	96	77	56	35	33	40	25	200	200	1.70	Heating
kWh/(m²month)	Radiation South	121	122	125	105	98	88	99	109	114	116	91	99	70	40	200	200	1.25	Cooling
kWh/(m²month)	Radiation West	40	51	76	86	105	105	113	103	77	58	35	30	45	30	200	200	1.50	Dehumidification
kWh/(m²month)	Horizontal radiation	55	76	116	141	177	187	196	167	122	86	51	42	50	35	350	350		
° C	Dew point temperature	-15.6	-12.6	-6.4	-0.2	6.4	12.5	15.5	14.5	9.8	3.2	-4.1	-11.8			18.5	18.5		
° C	Sky temperature	-39.1	-29.8	-17.7	-5.9	2.9	10.1	13.3	11.6	4.5	-6.9	-18.9	-33.1			16.4	18.5		
° C	Ground temperature	-10.1	-6.7	0.4	9.1	15.9	21.2	24.1	22.4	16.9	10.6	1.8	-6.7	-10.1	-10.1	24.1	24.1		
	Comment:	Source: Meteonorm																	



Main Modeling Output Parameters

- Space heating & heating load
- Cooling (latent + sensible) & cooling load OR risk of overheating

reflects performance of the building

- Hot water heating
- Electricity: Lighting, appliances, plug loads etc.

primary energy target incl. assumptions on occupant choices

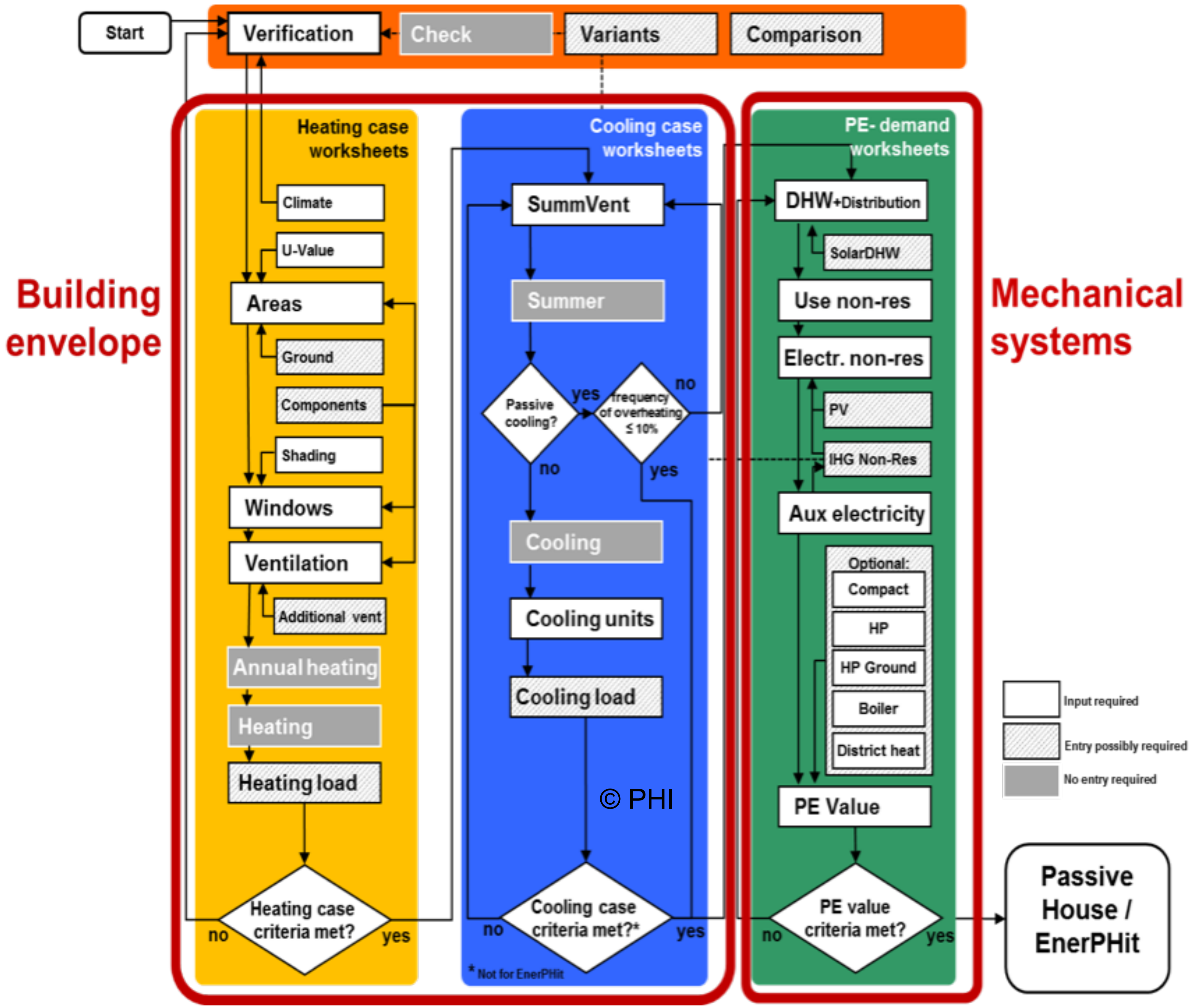
The PHPP is a Design Tool

Building: Hollis Montessori School

Climate data set: US0035a-Boston

Specific building characteristics with reference to the treated floor area			
	Treated floor area ft²	9058	Fullfilled?[2]
Space heating	Heating demand kBTU/(ft²yr)	1.70	yes
	Heating load BTU/(hr.ft²)	2.81	
Space cooling	Cooling & dehum. demand kBTU/(ft²yr)	3.47	yes
	Cooling load BTU/(hr.ft²)	2.49	
	Frequency of overheating (> 77 °F) %	-	-
	Frequency of excessively high humidity (> 0.012 lb/lb) %	0.0	yes
Airtightness	Pressurization test result n_{50} 1/hr	0.3	yes
Non-renewable Primary Energy (PE)	PE demand kBTU/(ft²yr)	14.77	yes

Building Optimization with the PHPP



Be pragmatic!

1. The air-barrier is the “holy” layer; nobody messes with the air-barrier without permission and a detailed plan!
2. Engineering to the exact 1/2” of insulation is not necessary.
3. Use what is readily available but do not stretch it beyond its capabilities.
4. Find expertise when you need it; never be afraid to ask for help.
5. If you do not understand the building science, find someone who does!
6. The best window on the market could still be much better for a very cold climate zone.
7. Shading is not optional.
8. Sometimes, a single spec is all that will do and that is okay.
9. If it saves in the long run, it is the better choice.
10. And no, open fires, combustion and exhaust-only devices will not work.

“Value Engineering”

Before we talk about cost: Building performance is directly responsible for climate change. Therefore, carbon-neutral building is not an optional extra and any building that does not fit a sustainable future contributes to the problem and is therefore obsolete!

1. First day cost only matter once, on day one. Life cycle cost matter over the entire life of the building.

2. Simple ROIs cannot deliver real value engineering. Owners do not control the cost of the resources their buildings consume but they can control the amount of resources they consume; e.g. low resource use = high cost control. Only energy-modeling enables real value engineering as it transparently illustrates the resource use, which drives cost.

3. An investment in the building envelope always pays off: A furnace dollar is 25-year dollar (plus maintenance, energy use and replacement cost); an insulation dollar is a life cycle dollar (no maintenance, no energy use and no replacement). Therefore, a building envelope dollar is always a smarter dollar spent = passive design.

How to set up a cold-climate
Passive House for success

Passive House Basics in Action

The 5 Passive House Principles

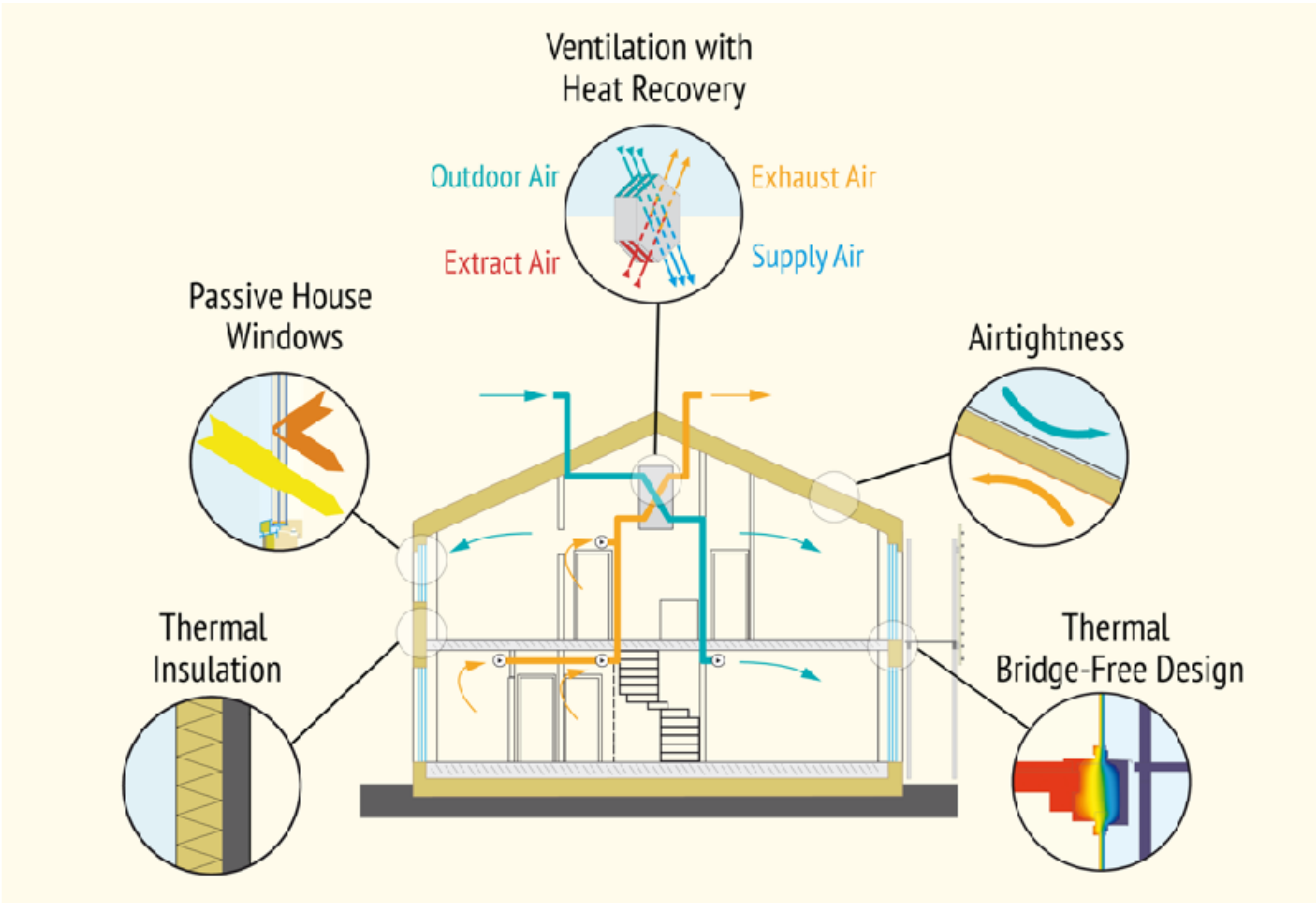
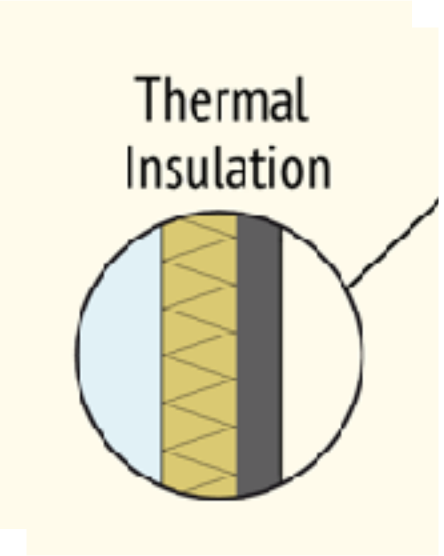
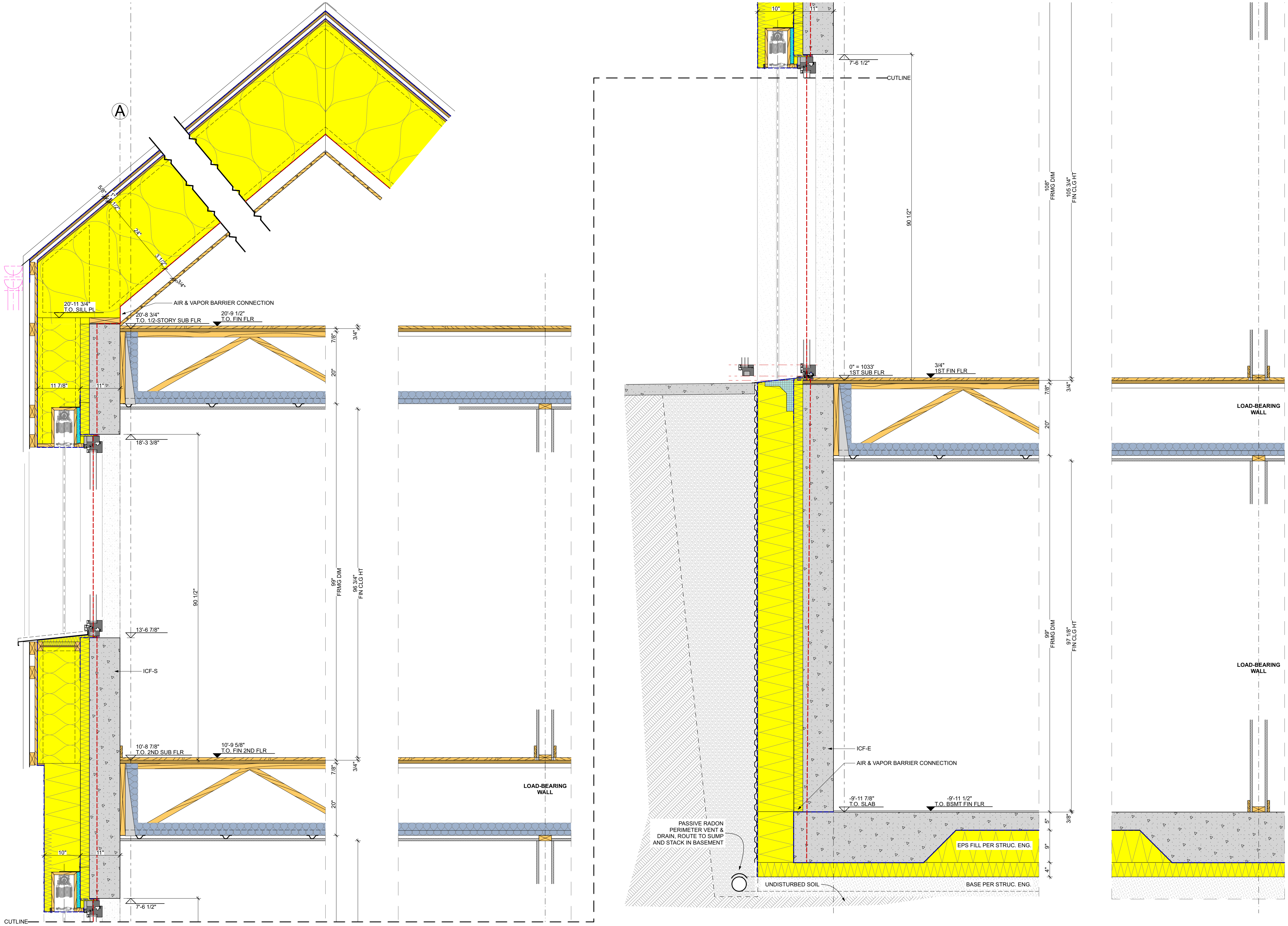


Image source: Passive House Institute, TE Studio

Continuous High R-Value Insulation





1 NORTH-SOUTH SECTION

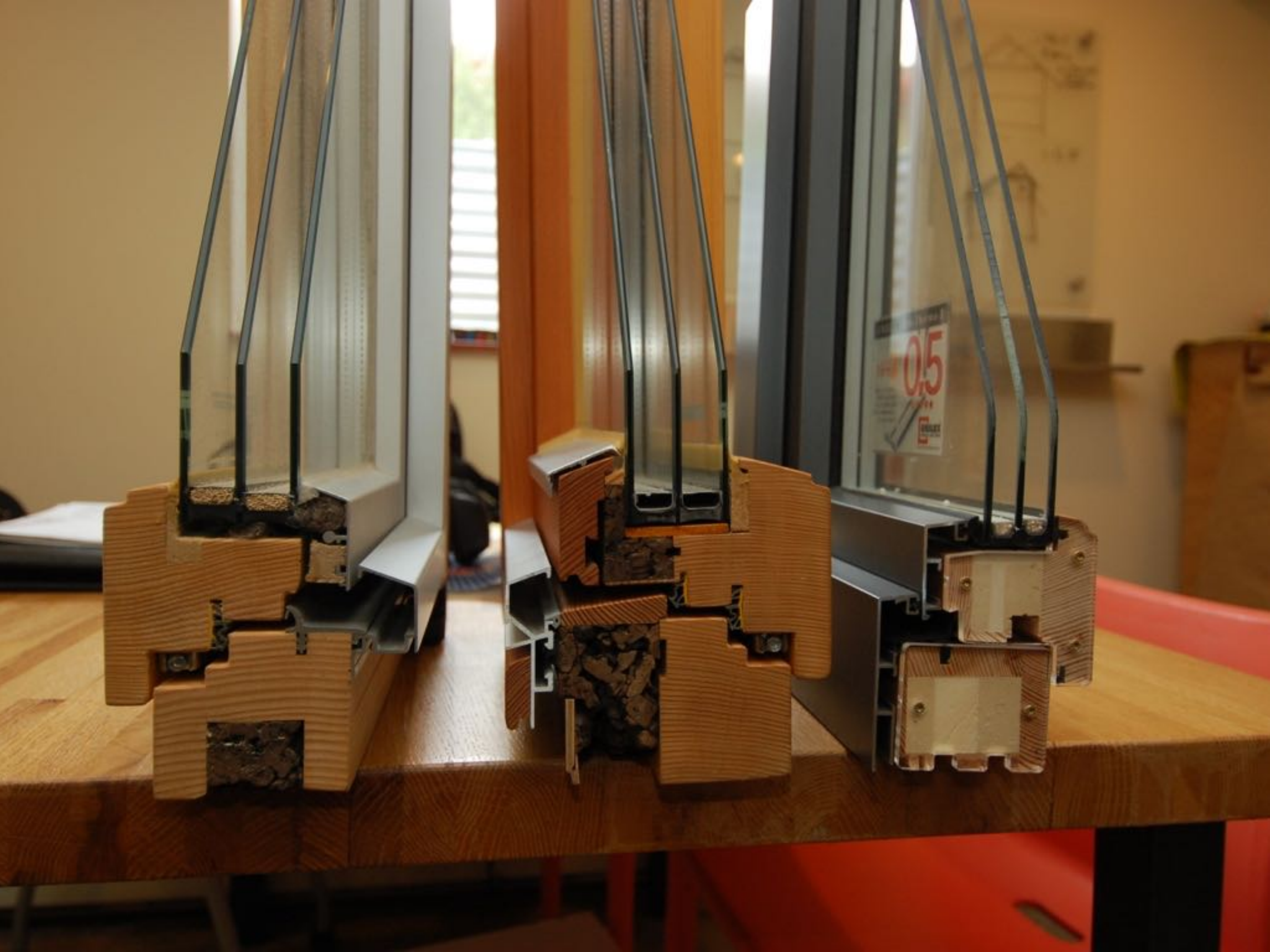
SCALE: 1" = 1'-0"

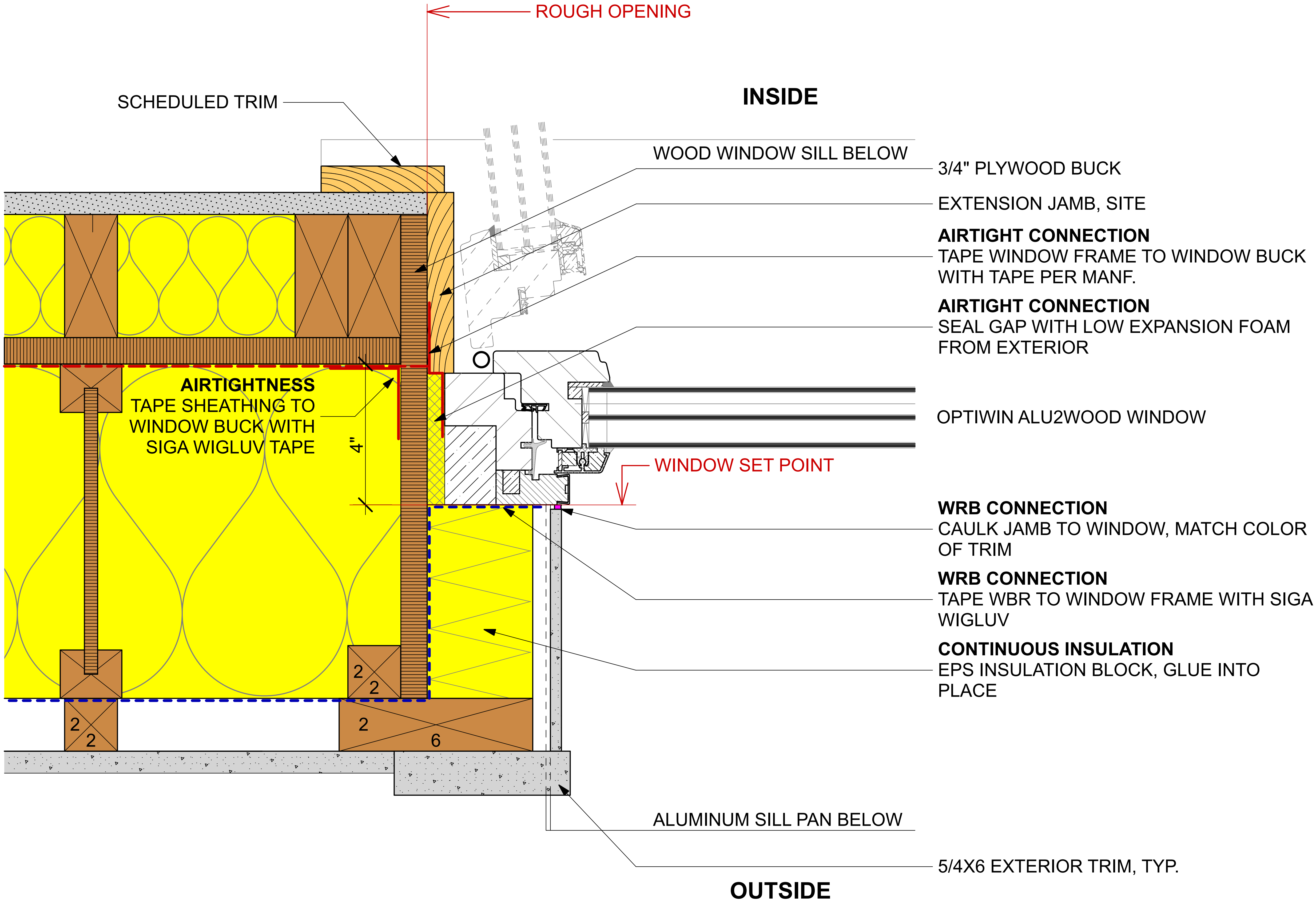

S185


SIGA-Wigluv
www.siga.ch


SIGA-Majvest
www.siga.ch

Passive House Windows And Doors

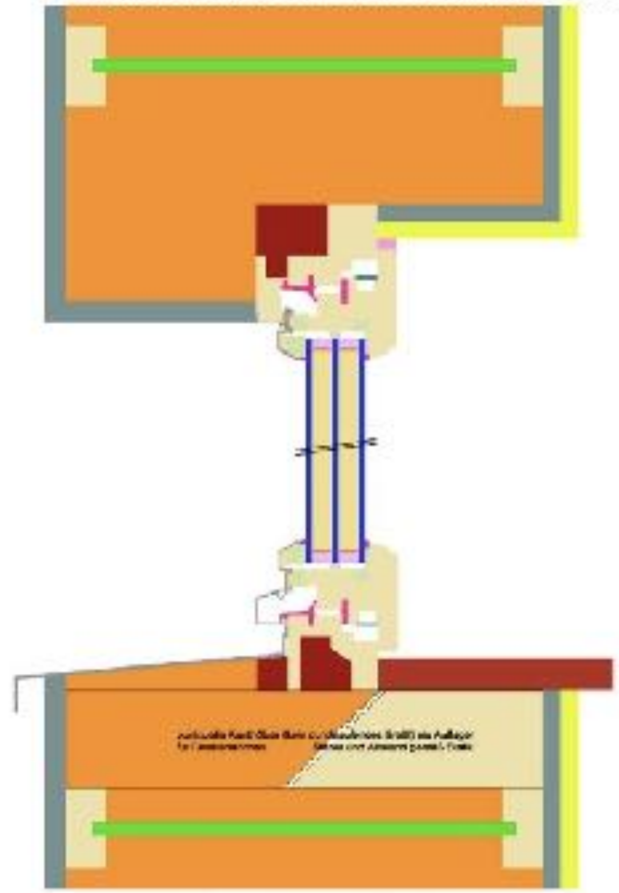

0,5

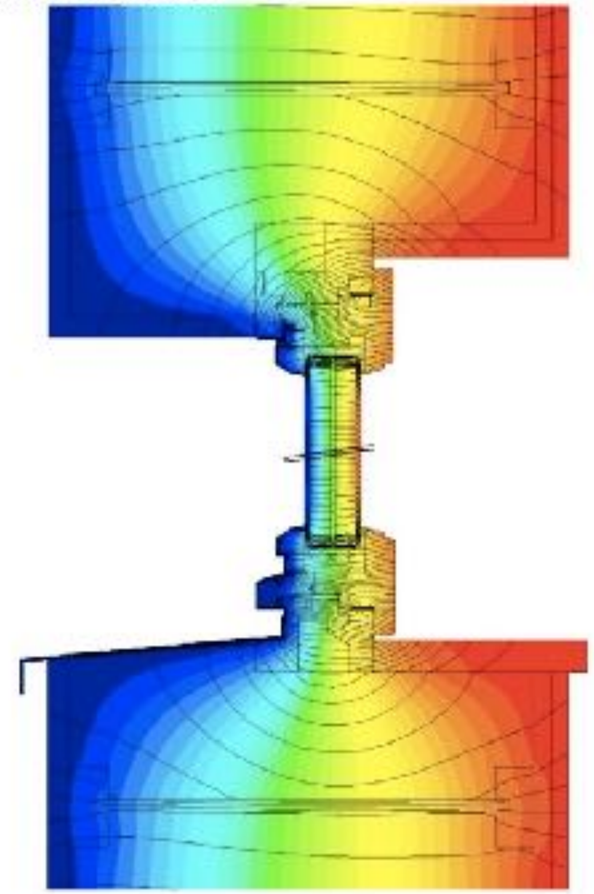
Proper installation starts with a detailed design

Understanding specifications

Datenblatt: Wärmebrückenfreier Anschluss



Einbau in Holzleichtbau-Wand



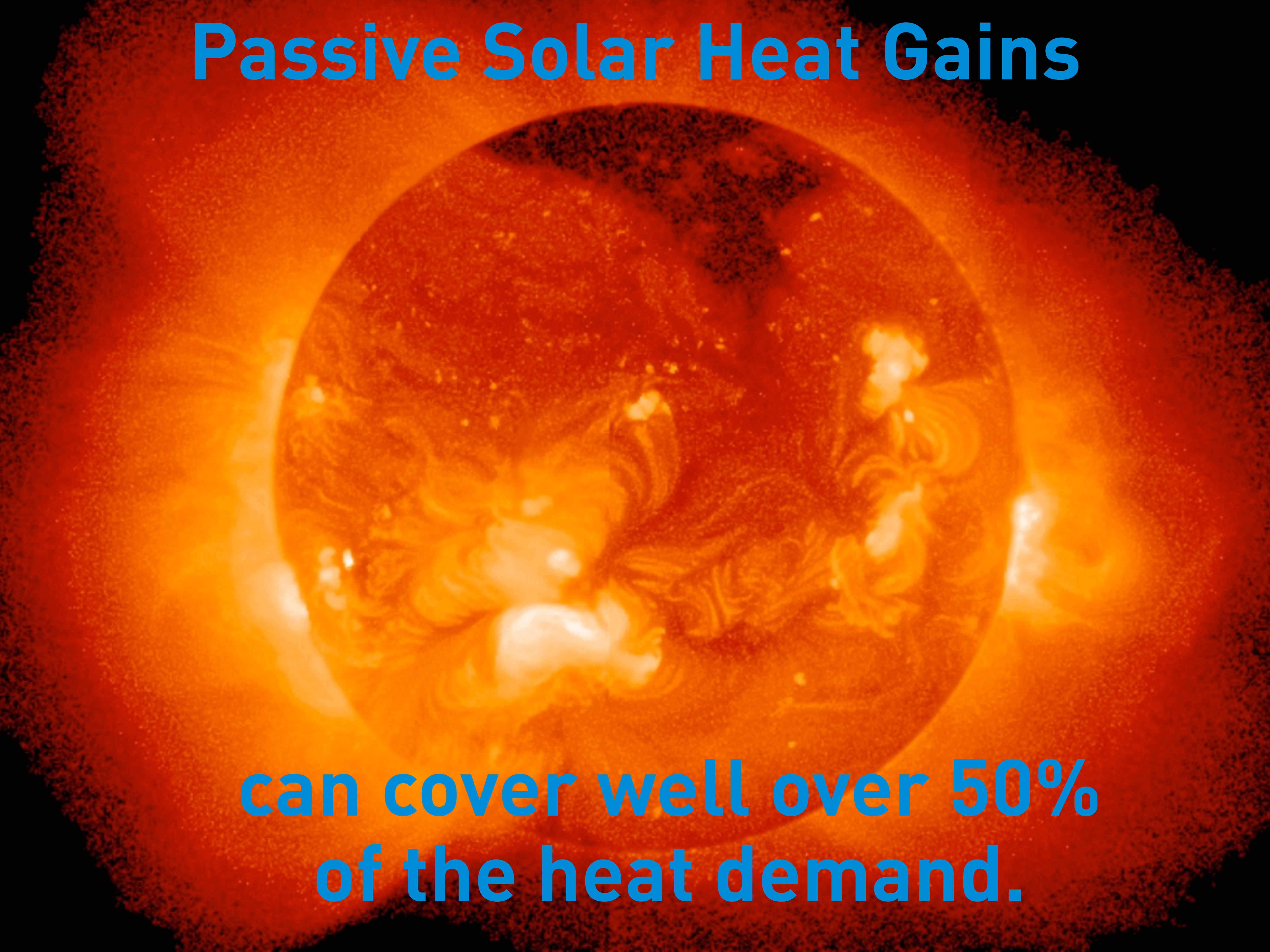
Isothermen- und Wärmestrombild

OPTIWIN GmbH 'Alu2Holz' Translation from German

Rahmen Holz mit Dämmstoffeinlagen aus Kork und Holzweichfaser.
Verglasung 44 mm mit U_g = 0,7 W/(m²K) ; (4/16/4/16/4)
Entwässerung über Aluprofil. Vollständig überdämmter Rahmen in Laibung und Sturz.
Nur punktuelle Auflager gemäß Statik zur Befestigung, kein durchlaufendes Laibungsholz.

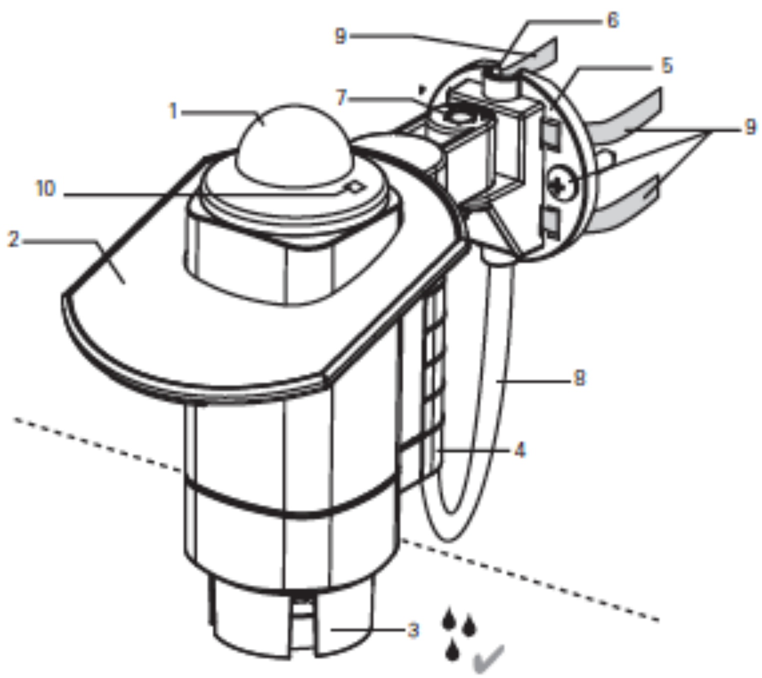
		Header/Jamb	Sill
Frame Values	U_f [W/(m²K)]	0,93	1,03
	Ansichtsbreite [mm]	119	114
Glass Spacer: Swisspacer V	Ψ_g [W/(mK)]	0,028	0,028
Glaseinstand	d [mm]	19	19
U_w-Wert (Fenster nicht eingebaut; 1,23 m x 1,48 m)	U_w [W/(m²K)]	(0,85) NA (different glass)	
Value for "over insulating" frame (U_{Wand} = 0,11 W/(m²K))	Ψ_{Einbau} [W/(mK)]	-0,003	-0,008
	$U_{w\,eingebaut}$ [W/(m²K)]	(0,84) NA (different glass)	
Hersteller:	OPTIWIN GmbH Wildbichlerstraße 1, A 6431 Ebbs email: office@optiwin.info	Tel.: 0043(0)5373-46046-12 internet: www.optiwin.net	
Berechnung:	Passivhaus Institut 2004		

Passive Solar Heat Gains



can cover well over 50%
of the heat demand.

Windows = Heaters

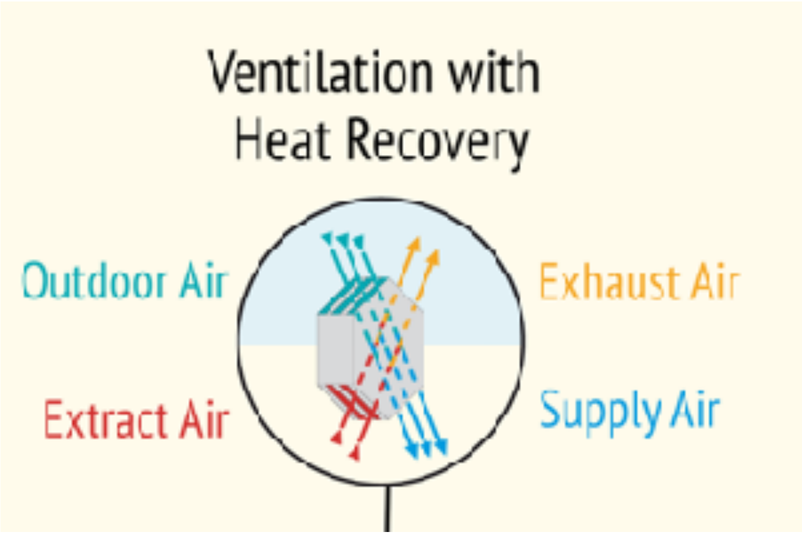


Heating Degree Hours:

107.1	
Transmission Losses	Heat Gains Solar Radiation
kWh/a	kWh/a
0	0
316	175
2521	5507
1551	1363
0	0
4389	7046

"Power is nothing without control"

Shading



Balanced Heat-Recovery Ventilation

Residential


CHARLOTTE PIPE


Level 1½

Commercial

Centralized


GOLD

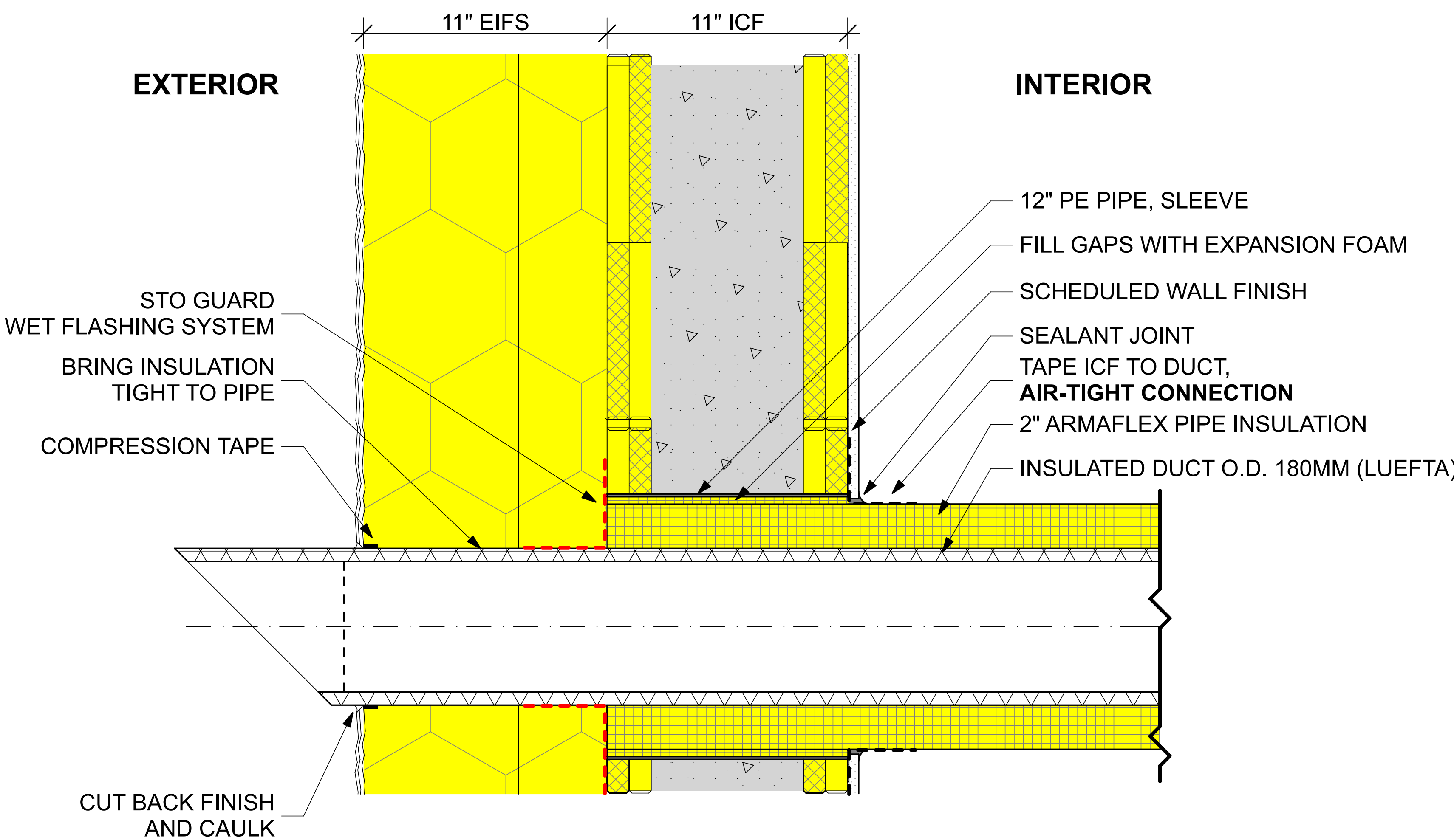

Decentralized

Continuous Airtightness

REFERENCE DETAILS:
- STO W 260

NOTE:
- USE ONLY STO CERTIFIED SEALANT
- COLOR MATCH CAULK TO FACADE COLOR

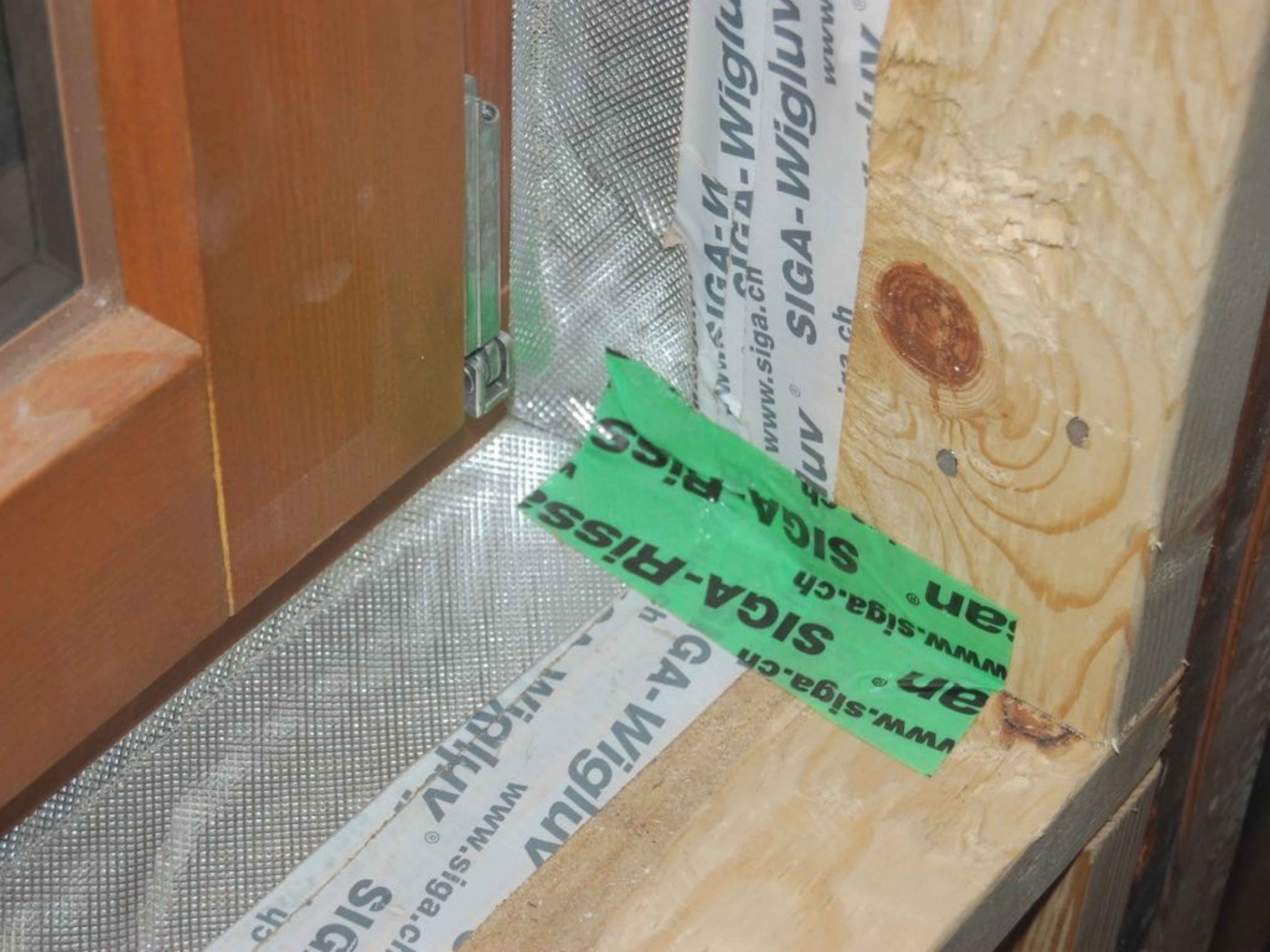
SUGGESTED INSTALLATION:
1) INSTALL PIPE
2) INSTALL COMPRESSION TAPE
3) INSULATE TIGHT TO PIPE AND COMPRESS TAPE
4) INSTALL FINISH SYSTEM



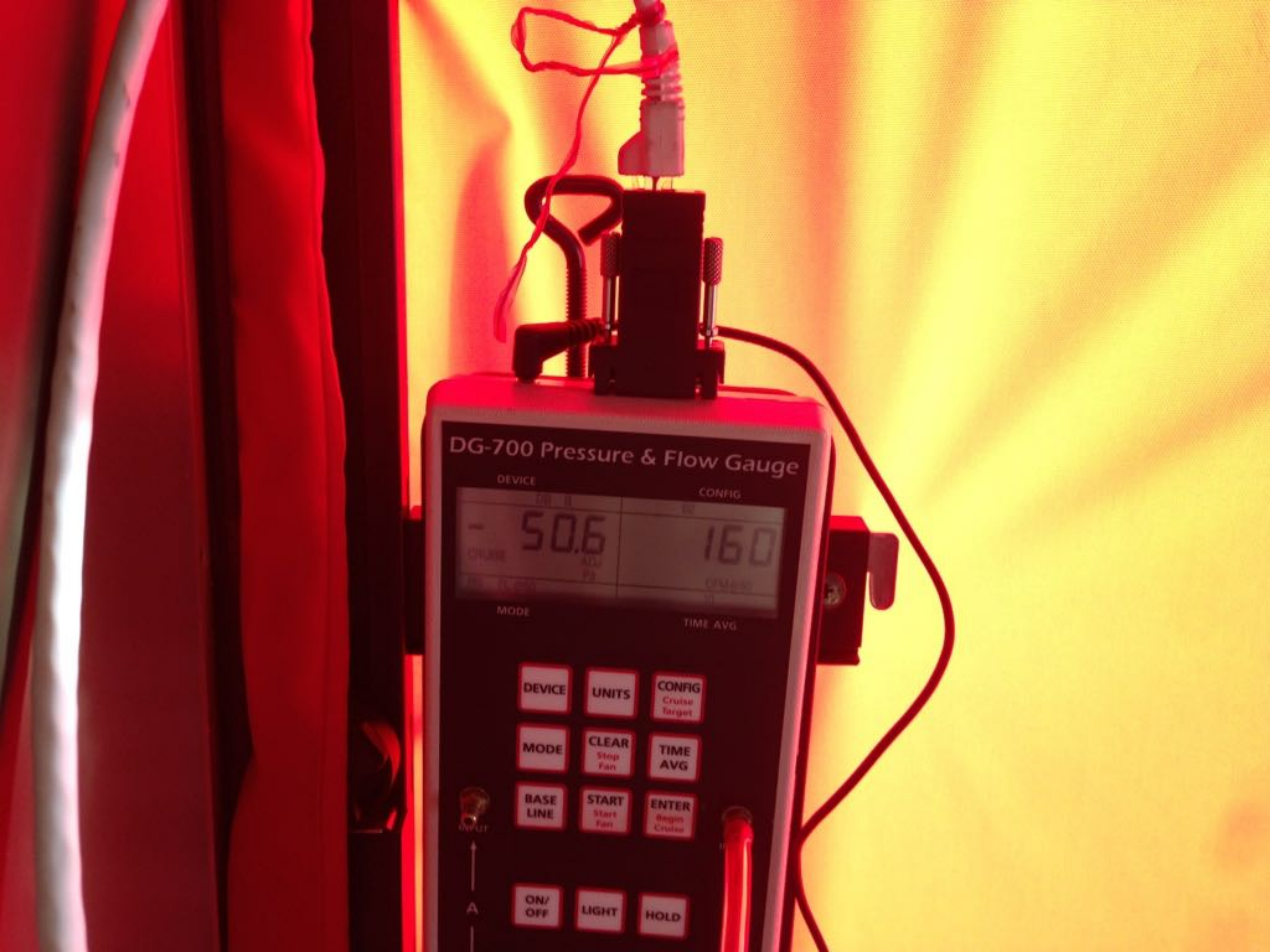
Airtightness starts with the design.

Once designed, air-tightness is easily managed on site.

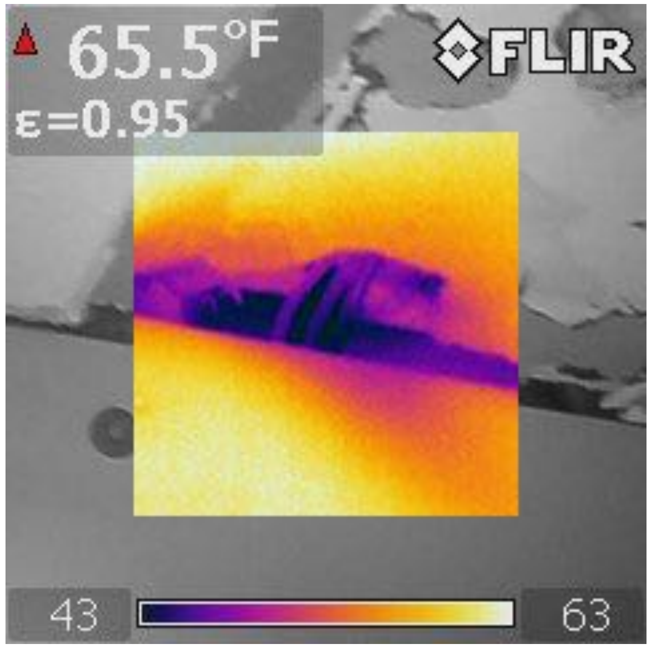

WATER SLEEVE
SHWR

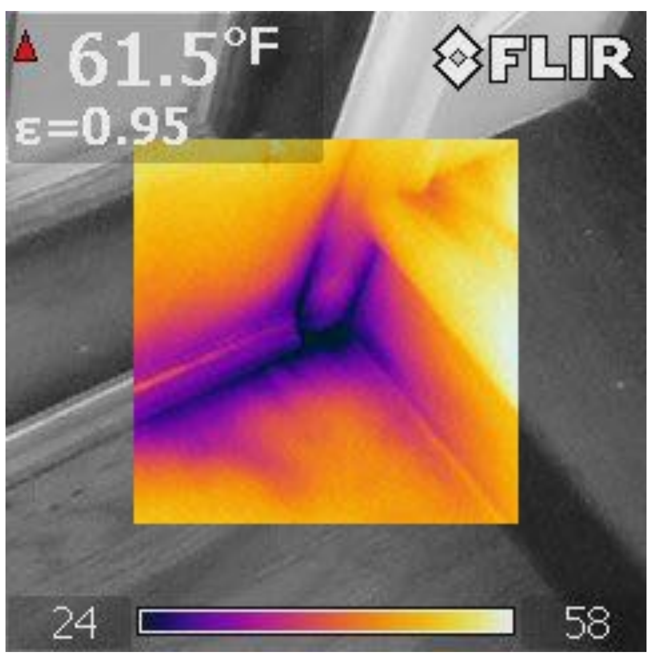

SIGA-Wigluv
www.siga.ch
SIGA-Riss

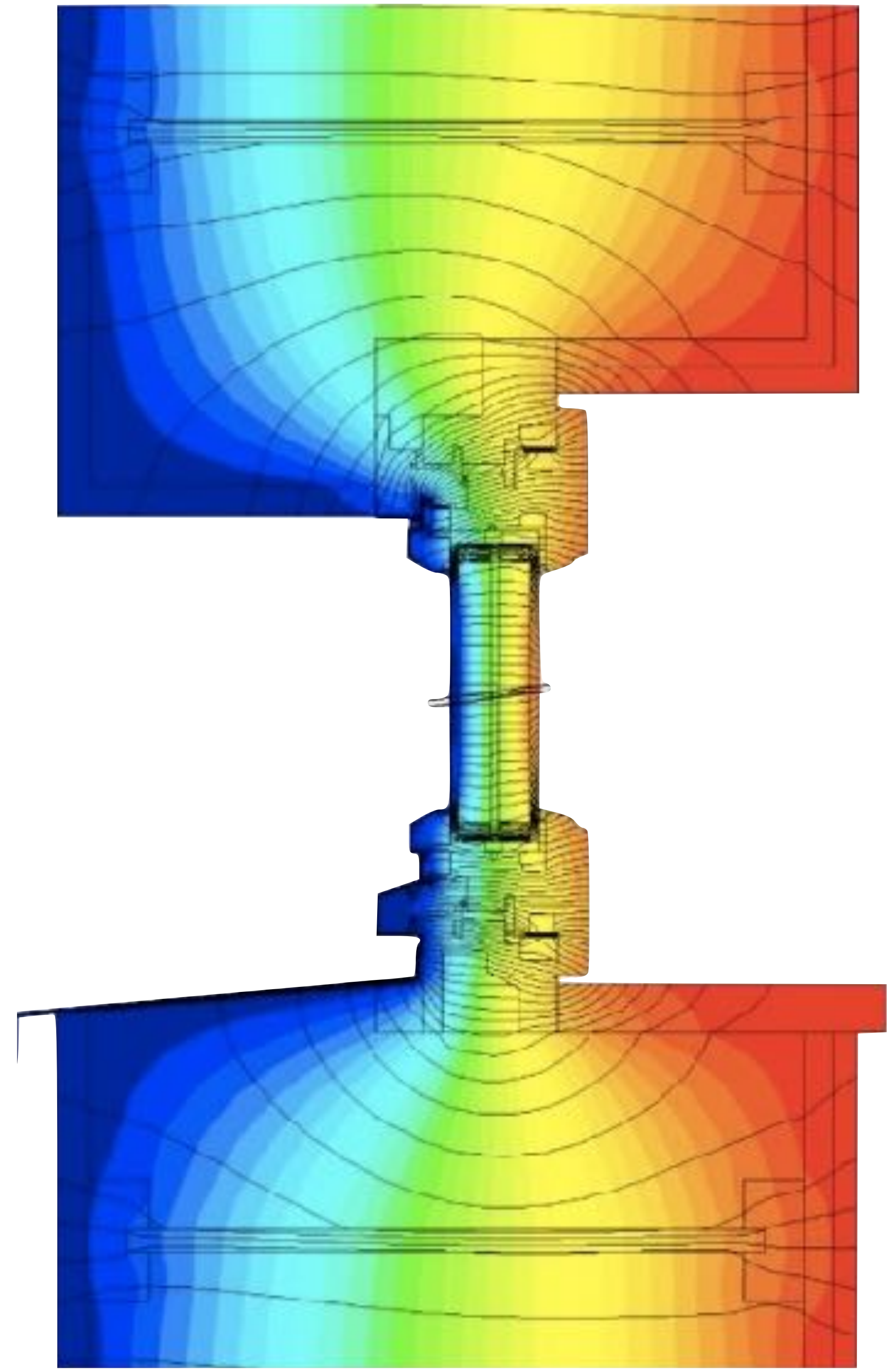

REWARD


DG-700 Pressure & Flow Gauge
DEVICE
CONFIG
50.6
160
MODE
TIME AVG
DEVICE
UNITS
CONFIG Cruise Target
MODE
CLEAR Stop Fan
TIME AVG
BASE LINE
START Start Fan
ENTER Begin Cruise
INPUT
A
ON/OFF
LIGHT
HOLD

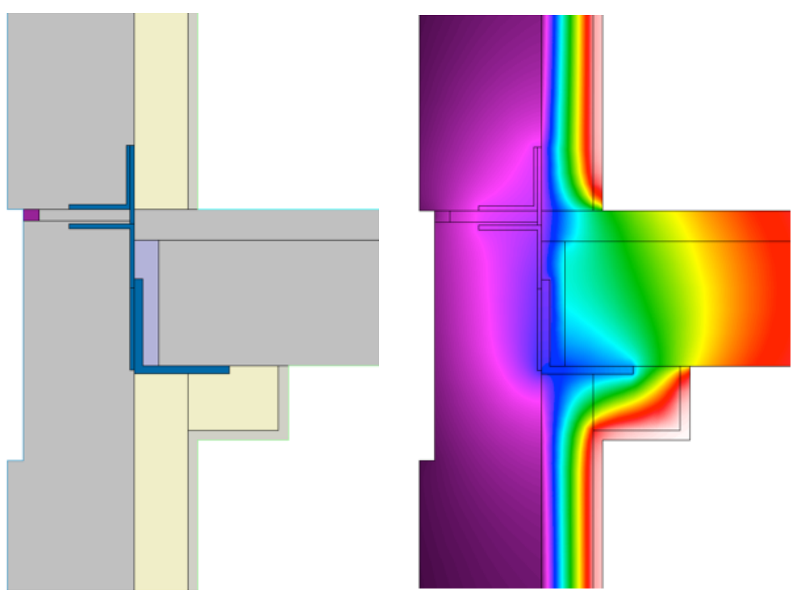
Thermal Bridge Free Design

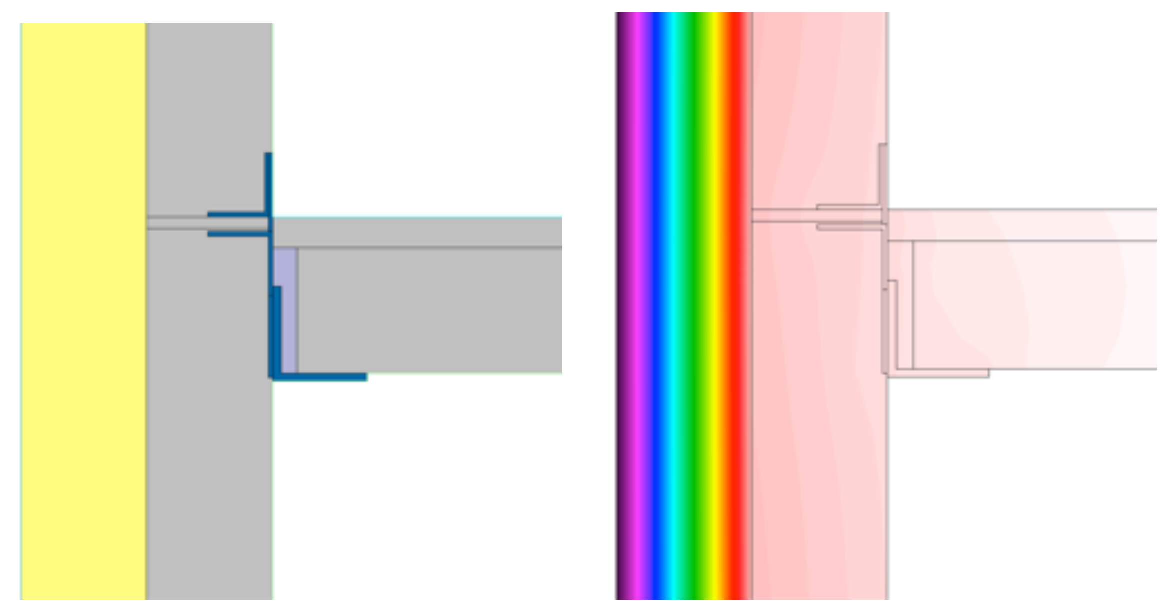






Understanding thermal bridges





$\Psi \leq 0.01$ W/(mK)

Thermal bridge-free by design

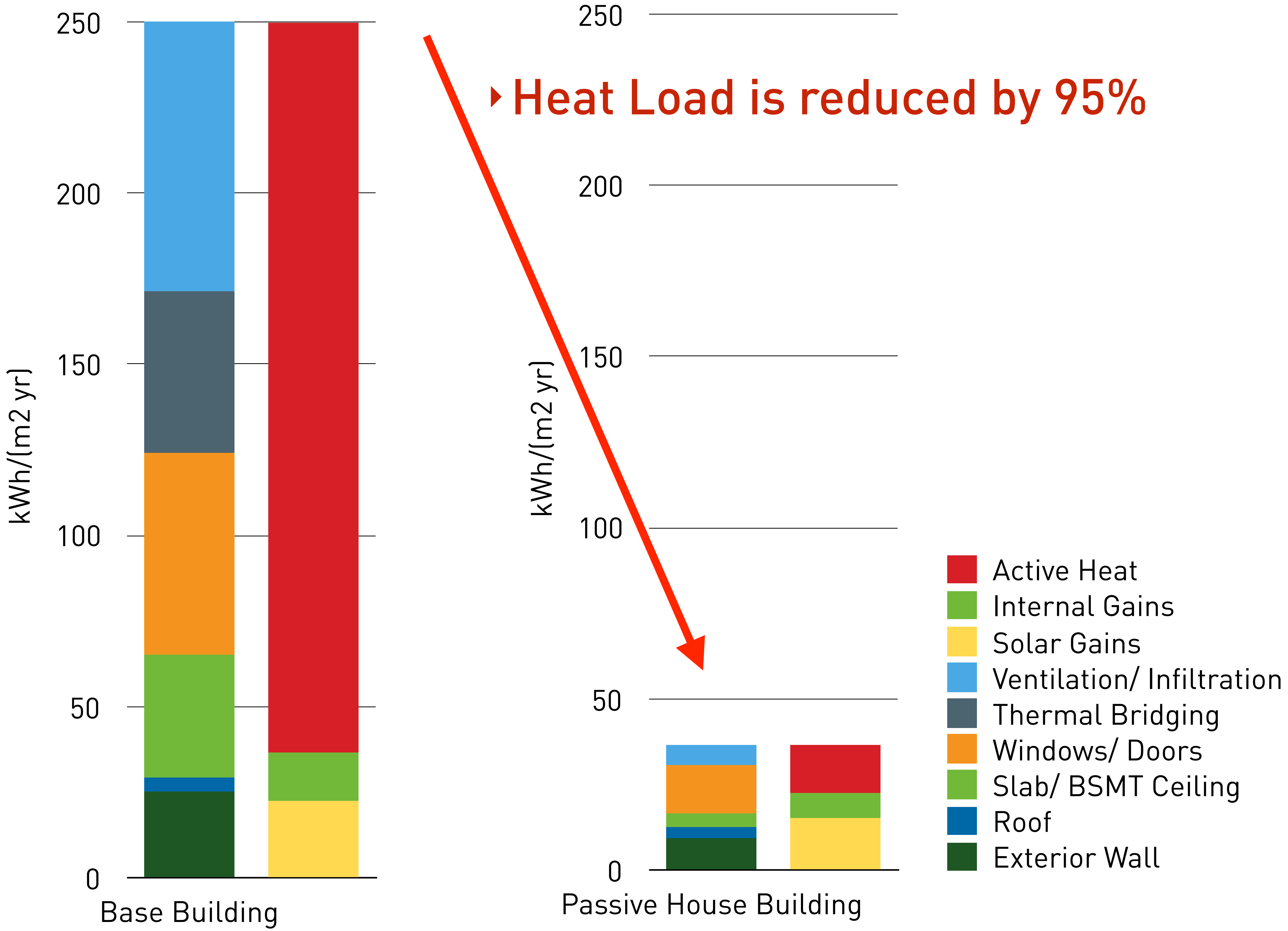
Internal Heat Gains

Cover a minimum of 10% of the heat demand.

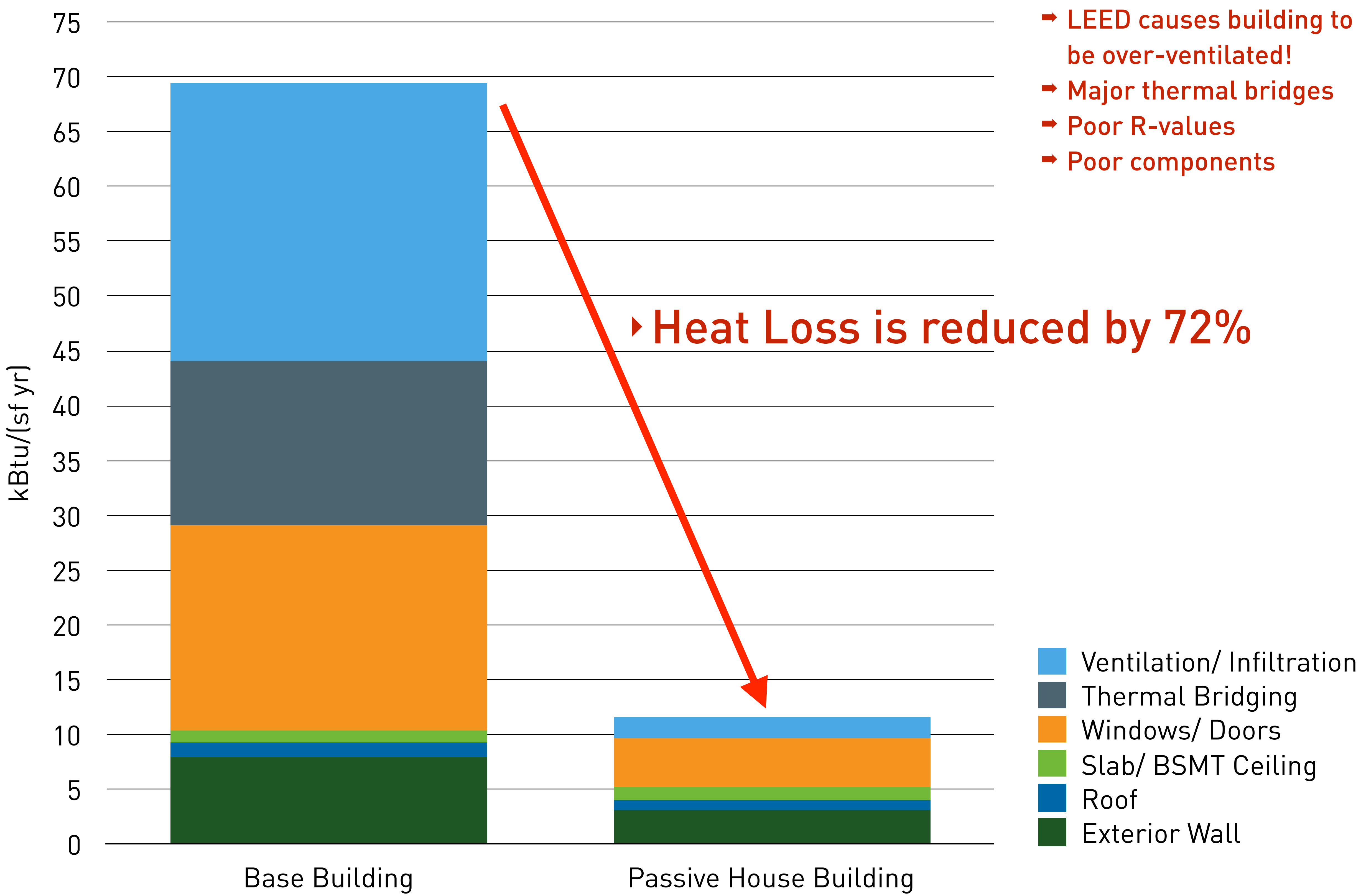
Image Source: Sony Pictures

Heating, Cooling & Dehumidification

Heat Flow Comparison



Heat Loss Comparison

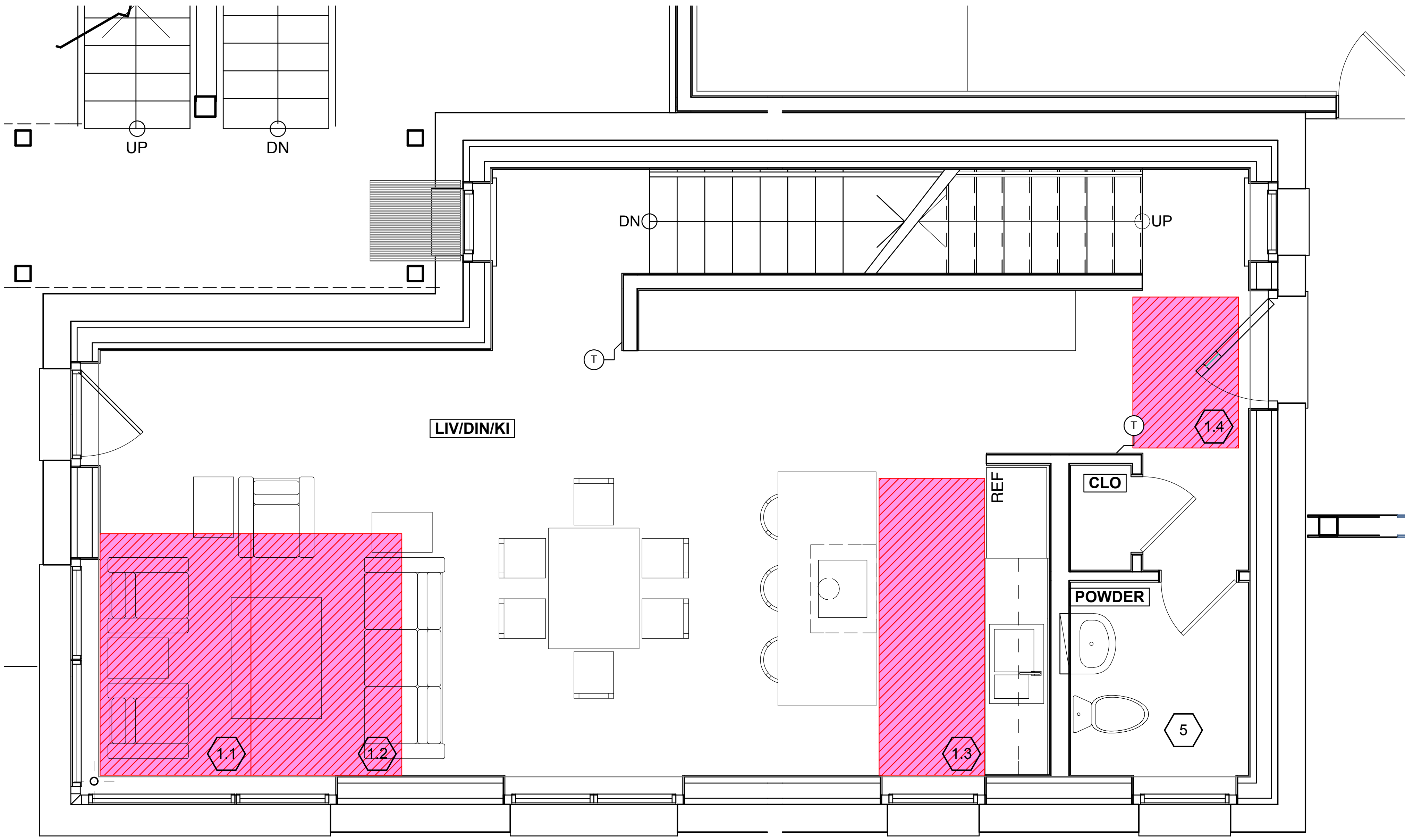


Heat/ Cooling Loads in MN Projects

Heat Loads: 3 - 6 Btu/(h sf)

Cooling Loads:1.5 - 6 Btu/(h sf)

Simple Systems



Residential Heat Pump Systems

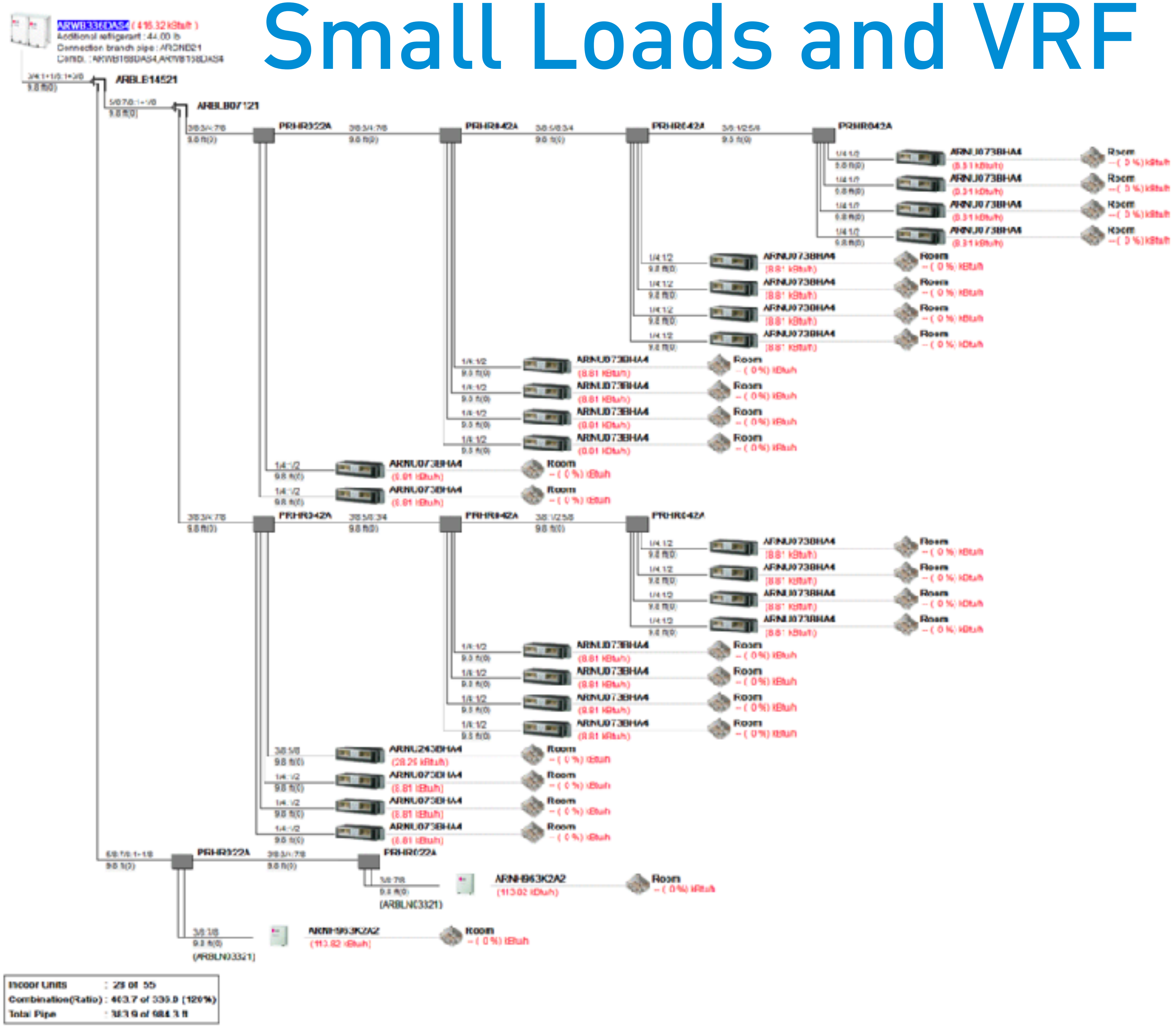

SIGA-Wigluv
www.siga.ch


FUJITSU

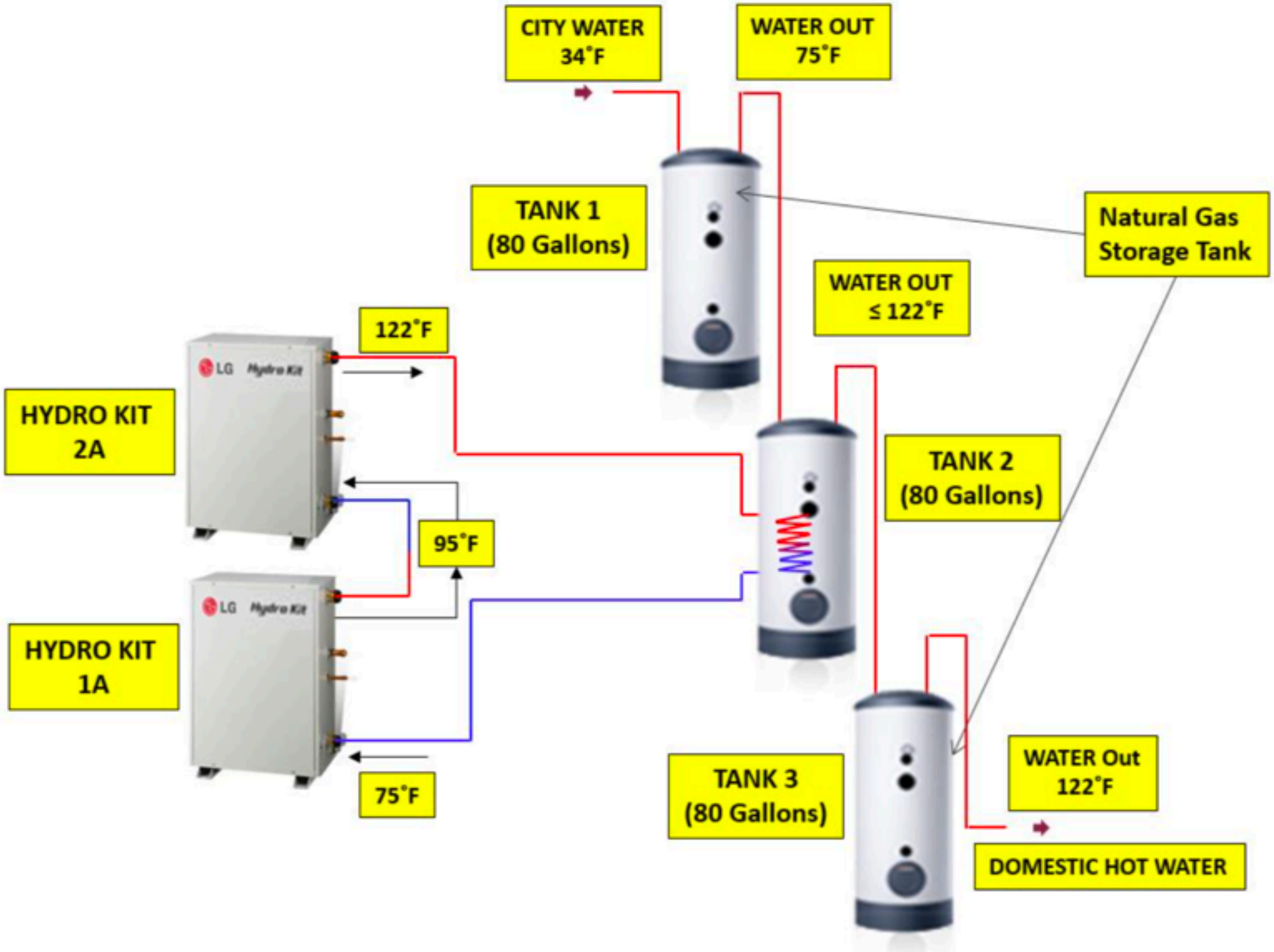
Commercial Heat Pump Systems

Image Source: LG

Small Loads and VRF



No Waste Heat



Building Science

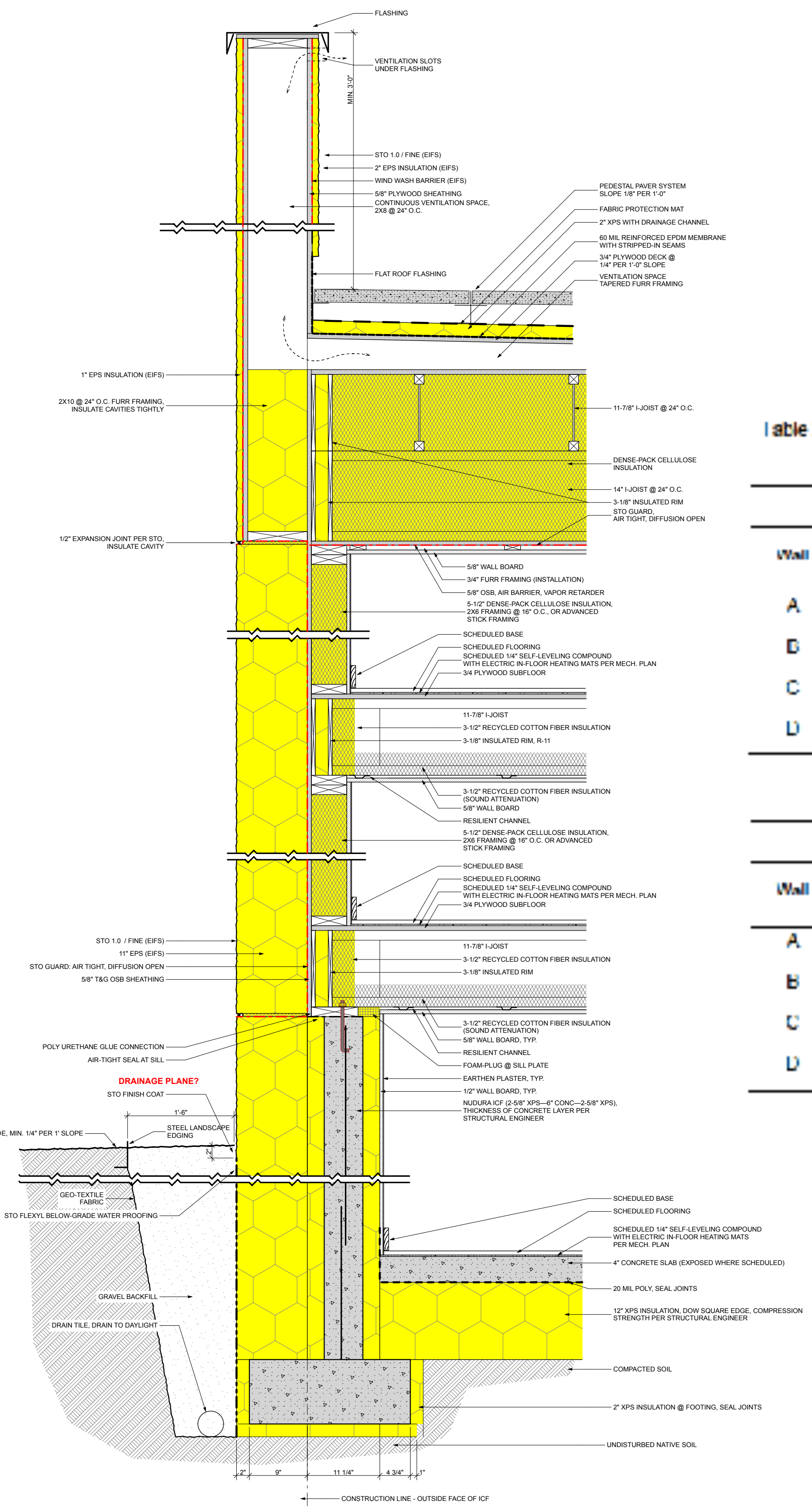


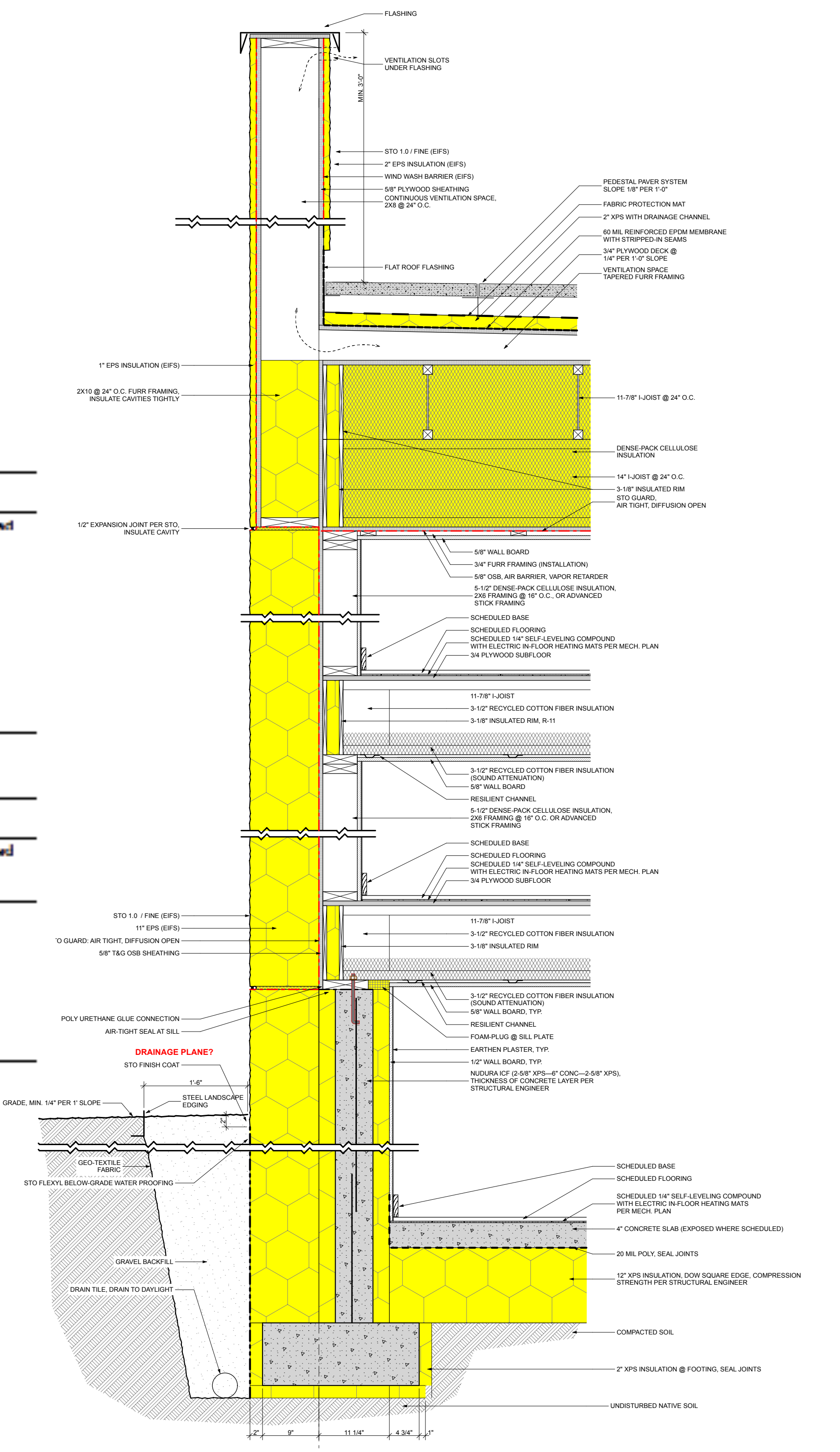
Table 2. Summary of Simulation Outcomes

Minneapolis Climate Data

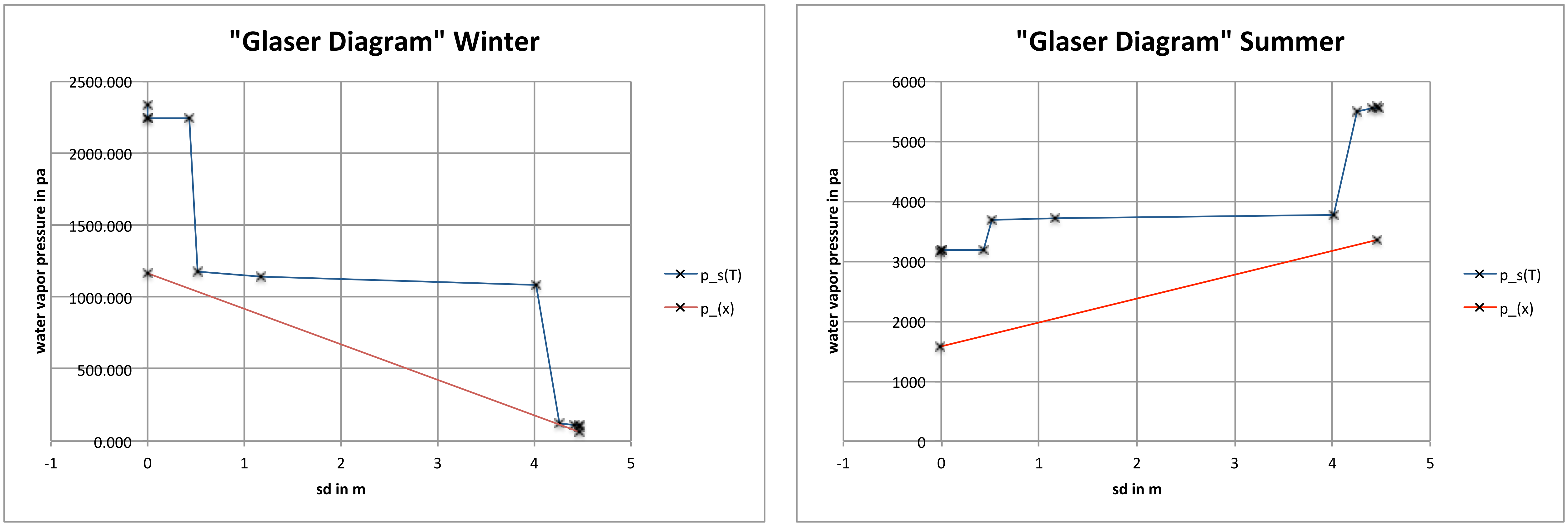
Wall	Interior Moisture Low	Interior Moisture Medium	Interior Moisture High	Infiltration Load 2%	Infiltration Load 4%
A	Pass	Fail	Fail	Fail	Fail
B	Pass	Pass	Fail	Fail	Fail
C	Pass	Pass	Pass	Pass	Fail
D	Pass	Pass	Pass	Pass	Pass

International Falls Climate Data

Wall	Interior Moisture Low	Interior Moisture Medium	Interior Moisture High	Infiltration Load 2%	Infiltration Load 4%
A	Fail	Fail	Fail	Fail	Fail
B	Pass	Fail	Fail	Fail	Fail
C	Pass	Pass	Pass	Pass	Fail
D	Pass	Pass	Pass	Pass	Pass



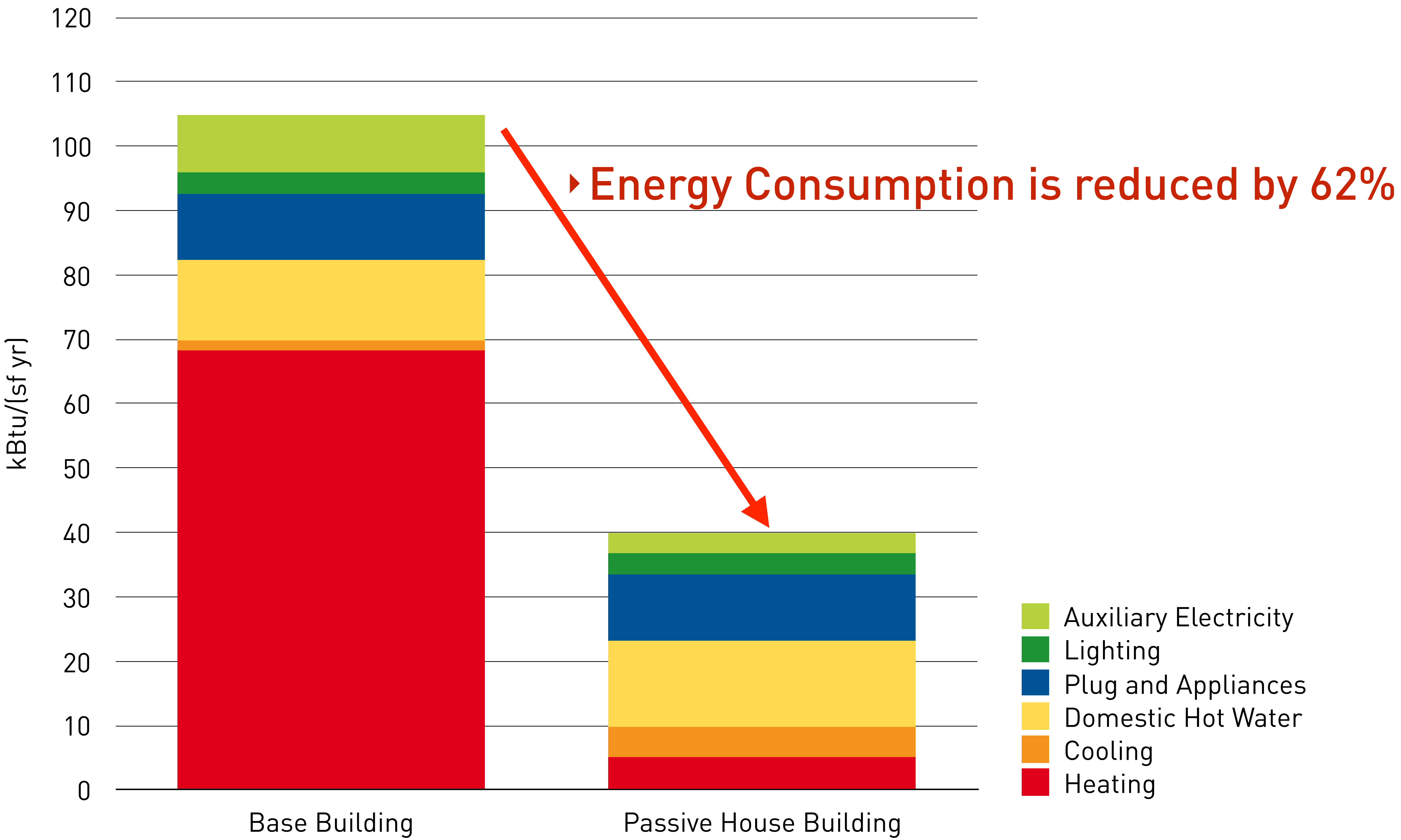
WuFi Analysis



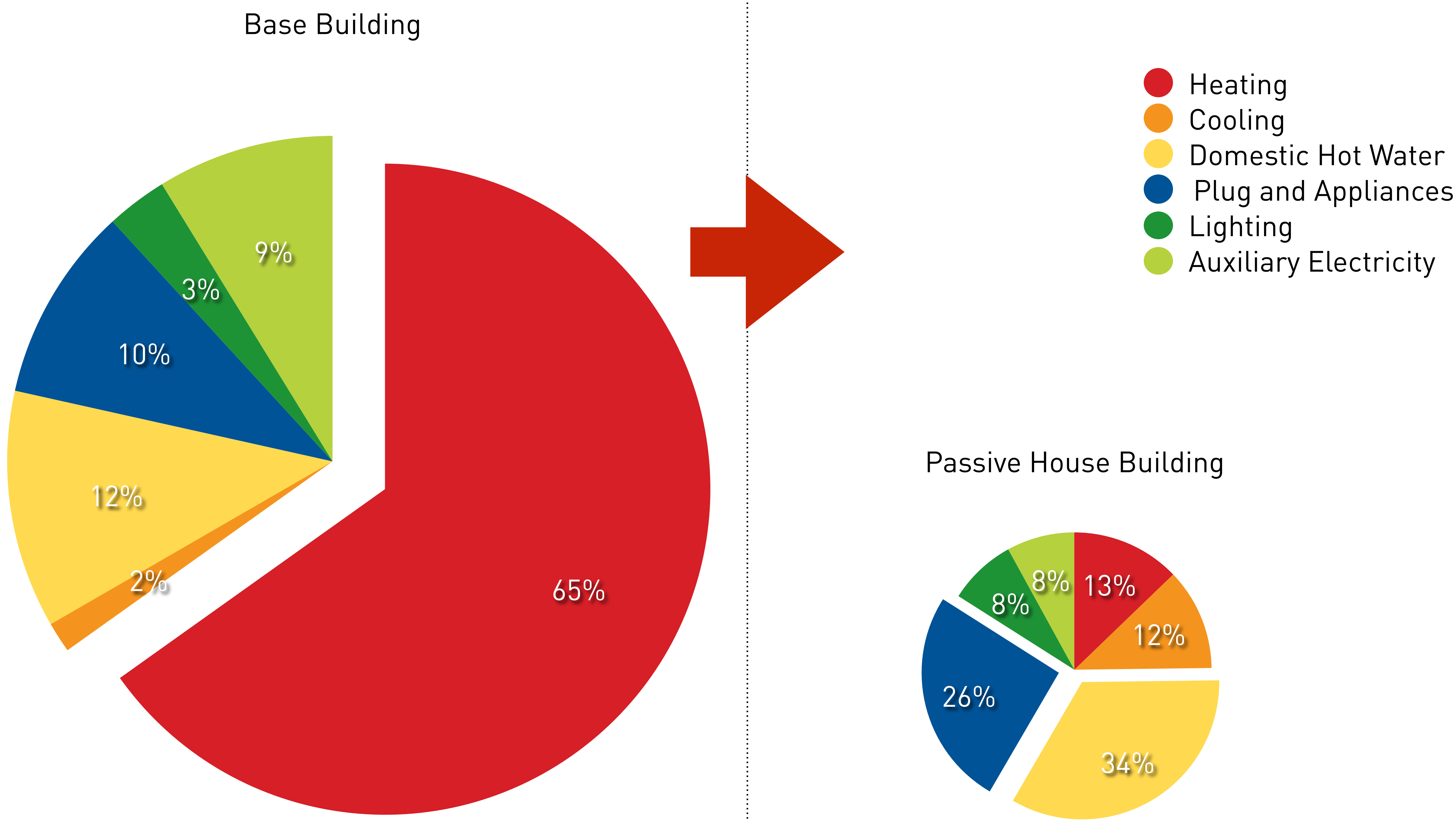
Glaser Diagram

Efficient Appliances and Equipment

Energy Consumption Comparison



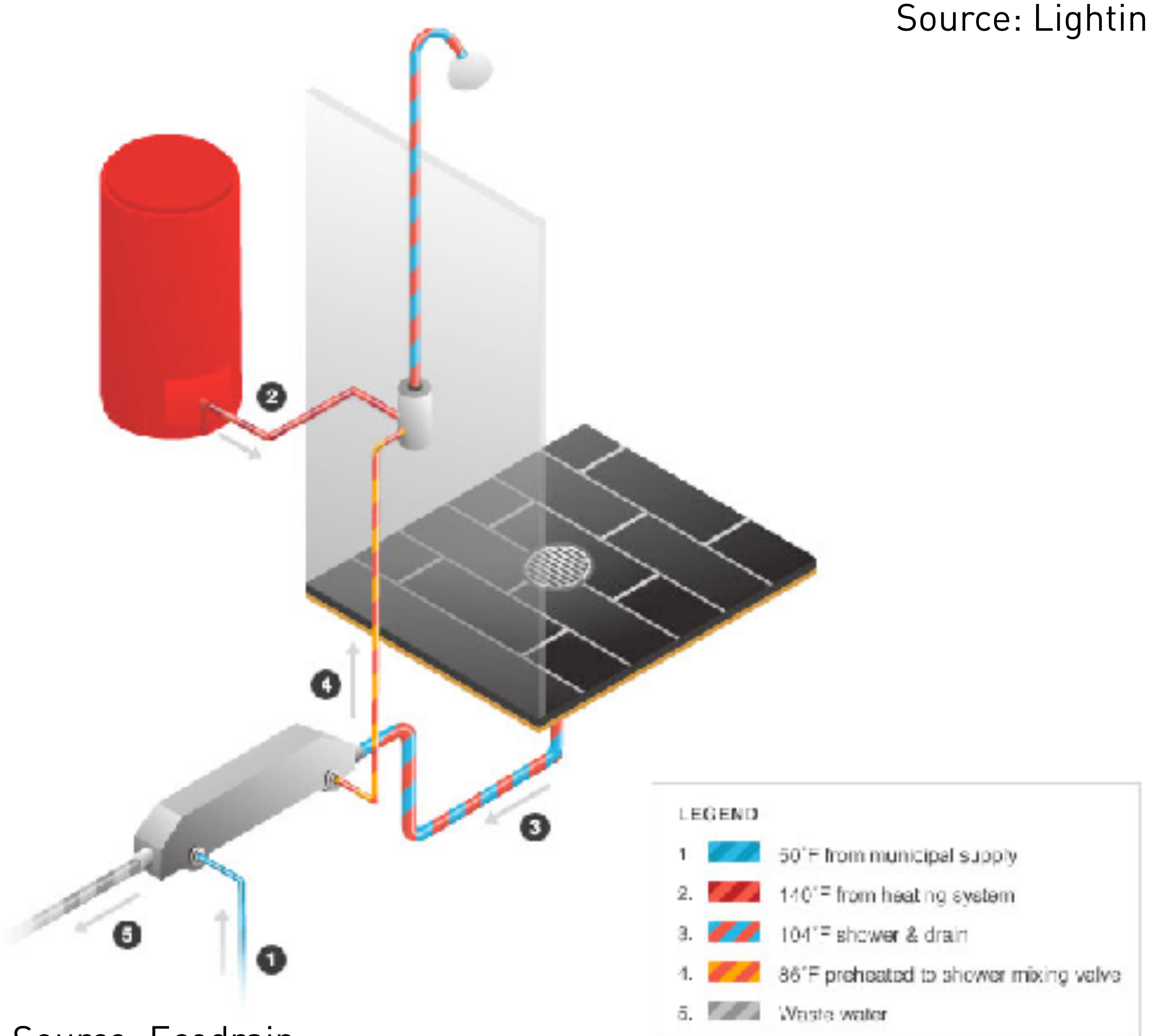
Energy Flow Comparison



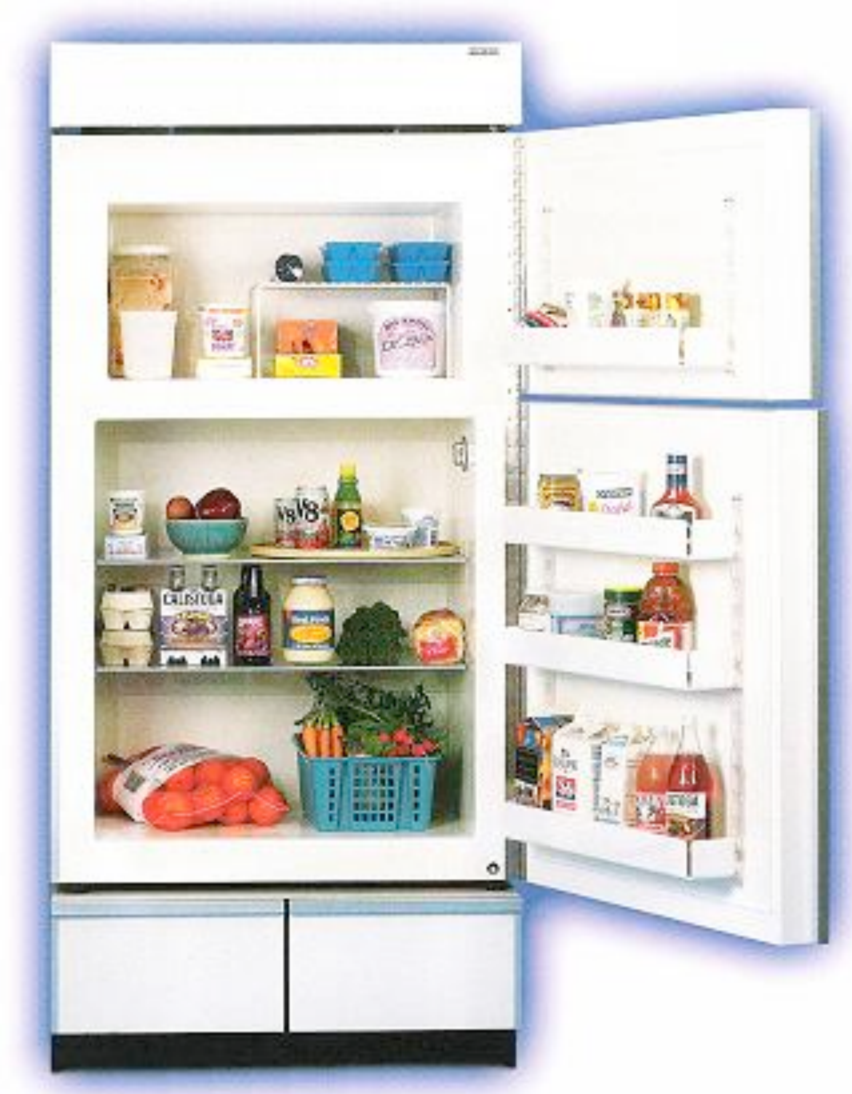
➡ Focus on heating load

➡ Focus on plug loads and domestic hot water

Source: Lighting Ever



Source: Ecodrain



Source: Sun Frost

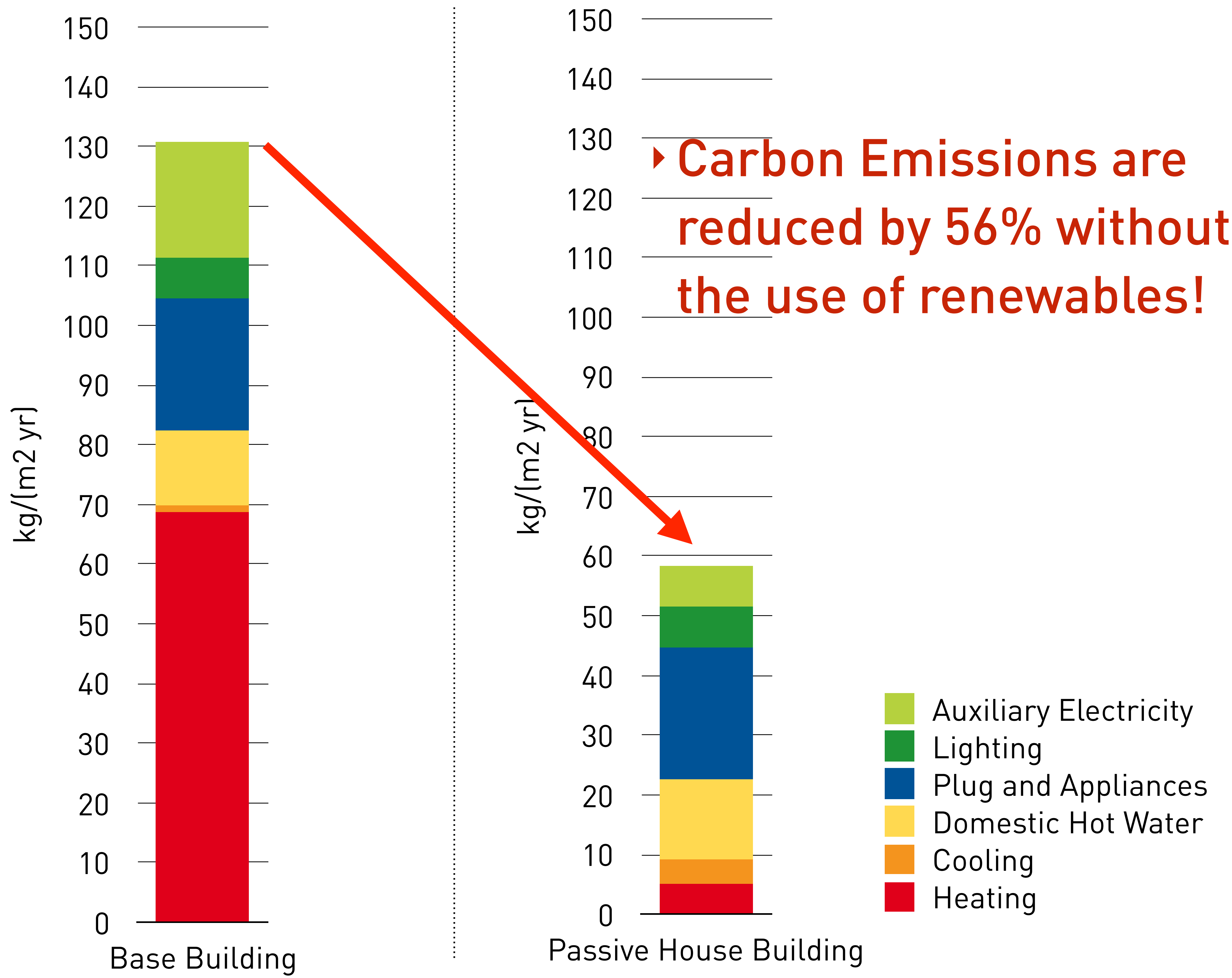
Monitoring


emonitor

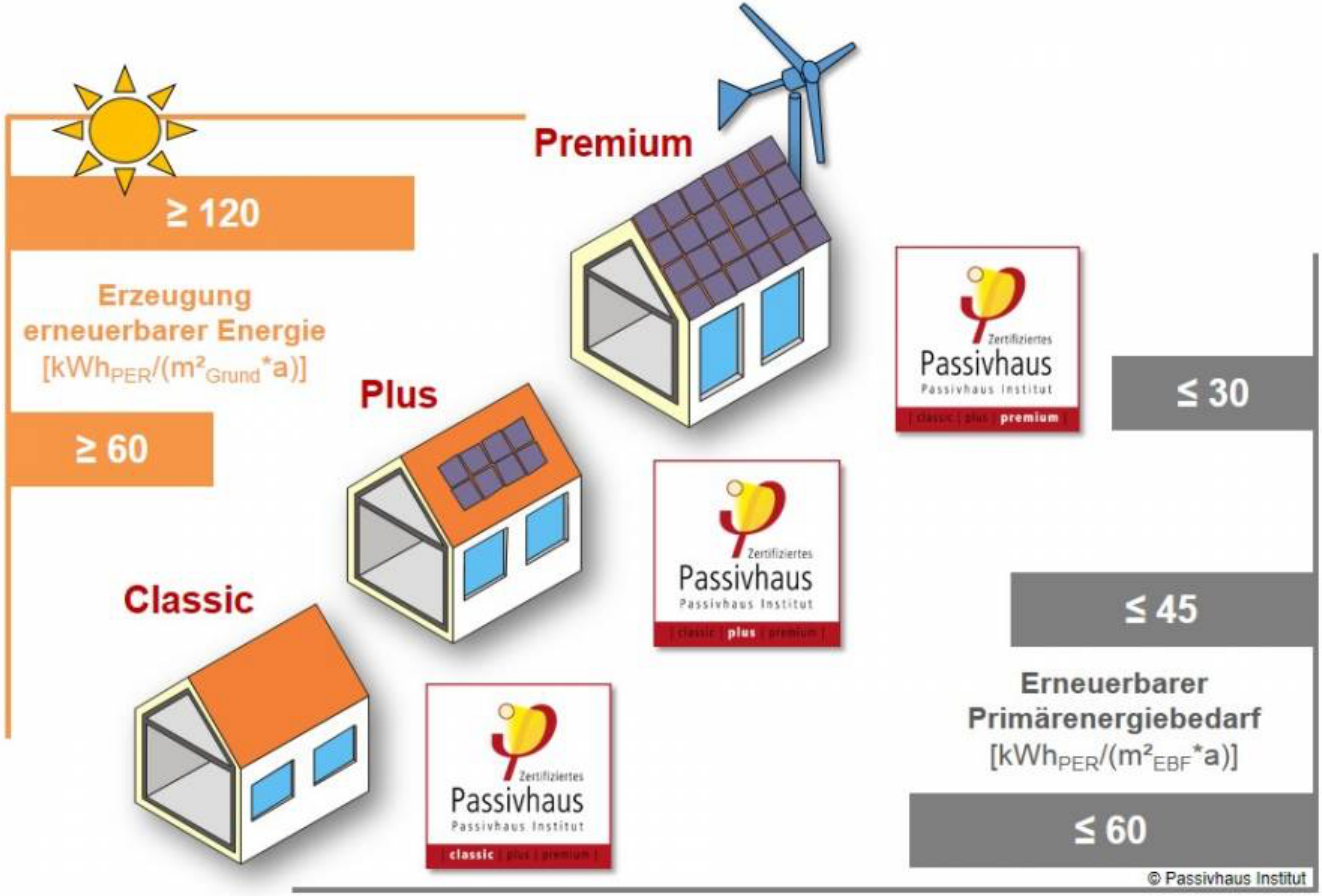

Powerhouse Dynamics
Welcome, Gary (Passive House in the Woods) Not Gary?
Settings | Support | Log Out
HOME
Circuits
Alerts
Ways to Save
Report Card
Local Weather
SiteSage Status:
Current use: 0.63 kW | $0.01/hr
Outside Temp: 29°F
Share My SiteSage Window
Utility Meter
Power Production
Top Appliances/Circuits On Now
30-Day Carbon Footprint
586 Watts
477 Watts
631w
Power Usage Now
Garage Sub Panel (513w)
Refrigerator (94w)
Outlets: Kitchen GFI #1 (34w)
Ventilator, Earthloop & L... (23w)
Outlets: Family Room (19w)
H2O Filtration, Solar The... (11w)
Outlets: Living Room (6w)
WI Avg.
My CO2
1294 lbs.
839 lbs.
30-Day
Phantom Power $1
Where I've used electricity in the past 30 days: Top 12 Circuits
Click a slice or label for detail / View All Circuits
Show All Slices
Garage Sub Panel 355kWh
Outlets: Kitchen GFI #1 82kWh
Outlets: Fam 75kWh
Heat Upper L 70kWh
Other Circuits 40kWh
H2O Filtrati 12kWh
Well Pump 15kWh
Ventilator, 31kWh
Refrigerator 33kWh
Heat Basement 38kWh
kWh
Cost
Electricity Usage in kWh by Month
This Month
76 kWh
636 kWh
Top 4 Users by kWh - Last 30 days
365 Garage Sub Panel
82 Outlets: Kitchen GFI #
75 Outlets: Family Room
70 Heat Upper Level

Renewable Energy Systems & Emissions

Carbon Emissions Comparison



Adding Renewables



Fuel responsibly for Carbon-neutral operation

Key Benefits

Highest Comfort

Image source: barefeetpoweryoga.com

Indoor Air Quality

Resource Efficiency

Image Source: dreamstime.com

Cheapest Life Cycle Cost

Image Source: dreamstime.com

Climate Action

Image source: artstreetic.com blu BLU

Resources

passivehouse.com

passipedia.org

passivehouse-international.org

naphnetwork.org

phmn.org

Training and Education

Passive House Institute

- Worldwide training and network of accredited course providers
- Worldwide certification system for building professionals
- Course material / e-learning modules in different languages

PHPP

Contractor Training 2019 Minneapolis

naphn
North American Passive House Network

naphnetwork.org

Thank You!

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