ENERGY DESIGN
conference & expo

# Passive House
# for Commercial Projects

CERTIFIED PASSIVE HOUSE DESIGNER

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

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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

1. Introduction and relevant work

2. The Passive House Building Energy Standard

3. Case Study 1: BioHaus Environmental Living Center

   North America's first certified Passive House in Bemidji, MN

4. Case Study 2: State of South Dakota

   Impact of Passive House for the State of South Dakota

5. Case Study 3: Hongqiao Lvyuan Condos

   EnerPHit (Passive House retrofit) in Shanghai, China

6. Case Study 4: Hook & Ladder Apartments

   Affordable multi-family housing in Minneapolis, MN

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Tanner

Tim
Eian

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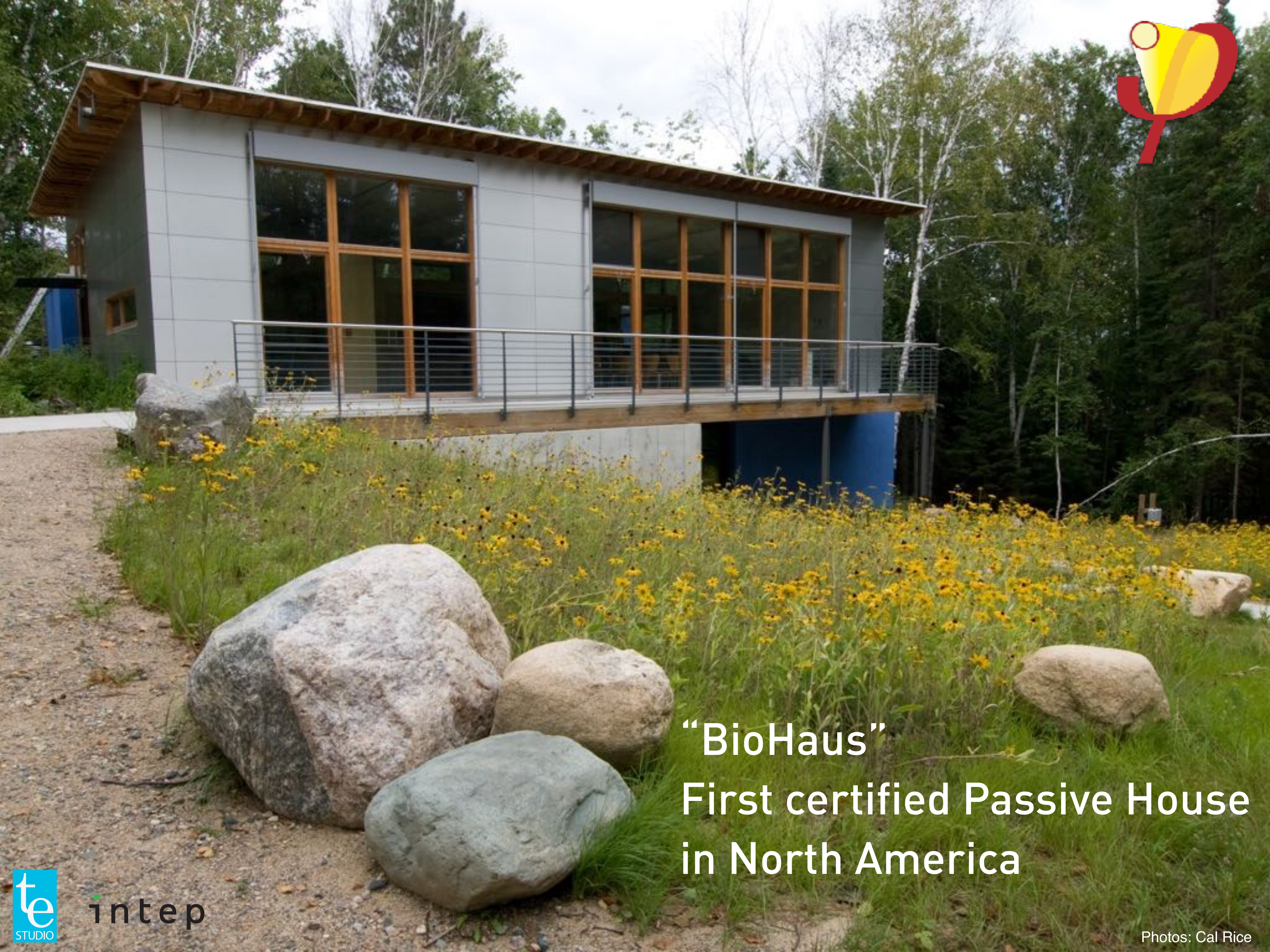
Building Performance, Measured Results

# Milestones


"BioHaus"
First certified Passive House
in North America
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Photos: Cal Rice

Photos: Cal Rice

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Photos: Cal Rice

# Impact of Passive House
# State of South Dakota

# Passive House Retrofit
# Hongqiao Lvyuan, Shanghai

# Hook & Ladder Apartments
## Minneapolis, MN

# The
# Passive House Standard

# Passivhaus - Passive House

EnerPHit

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

PHI **Low Energy** Building

"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

# Case Study 1

## Waldsee BioHaus - Environmental Living Center

Bemidji, MN - 2006/16

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# Project

**North America's first certified Passive House building. 10 years of operation. Ground zero for Passive House in the United States.**

- Energy performance over a decade
- Performance comparison with other standards
- Operating a Passive House
- Key Conclusion and Benefits

# 10-year Update

## Waldsee BioHaus, North America's first certified Passive House

Average energy use since 2006: 33kWh/($m^2$ yr), or 10,500 Btu/(sf yr)

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Passivhaus Institut
Dr. Wolfgang Feist
Rheinstr. 44/46
D-64283 Darmstadt

# Certificate

**The Passive House Institute awards the building**

**das BioHaus - the Environmental Living Center at the Waldsee**
**8659 Thorsonveien NE, Bemidji, MN 56601, Minnesota/USA**

Principal: **Concordia Language Villages**
8659 Thorsonveien NE, Bemidji, MN 56601, Minnesota/USA

Architect: **Intep, LLC**
301 White Street, Minneapolis/Watertown, MN 55388, Minnesota/USA

Mechanical Services: **Intep, GmbH**
Innere Wiener Strasse 11, D-81667 München, Germany

**the certificate**

## Quality Approved Passive House

**The planning of this building meets the criteria for Passive Houses set up by the Passive House Institute.**
**With appropriate execution it will conform to the following standards:**

- The building features excellent heat insulation all around and first grade component joint details in regard to building physics. Estival sun protection has been considered. Heat requirement is limited to

***15 kWh per m² living area and year***

- The building shell features excellent air tightness proven according to ISO 9972 which guarantees to be free of draught as well as little energy consumption. Air change rate of the building shell at 50 pascal pressure differential is limited to

***0,6 ach, in reference to the building's volume***

- The building features a controlled ventilation system with high class filters, highly efficient heat recovery and low electric power consumption. Thus, excellent air quality together with low energy consumption are achieved.
- The demand in primary energy for heating, warm water, ventilation and household electricity totals with standard use less than

***120 kWh per m² living area and year***

This certificate is to be used together with the certification documents only. From these the precise data of the building can be obtained.

Passive Houses offer high comfort in summer as well as in winter conditions and can be heated with little effort, e.g. by heating of supply air. The building shell of a Passive House is evenly warm on the inside, inside surface temperatures are hardly different from room air temperatures. By means of the high grade air tightness drought appearance is impossible in normal use. The ventilation system steadily provides good air quality. Heating costs in a Passive House are very low. Due to little energy consumption Passive Houses offer a high rate security against future rise in energy prices and energy scarceness. Moreover the environment is ideally protected as energy ressources are spent very economically and only small amounts of carbondioxide ($CO_2$) and other concentrations are emitted.

**issued:**
**Darmstadt, April 12, 2006**

**Dr. Wolfgang Feist** Wolfgang Feist

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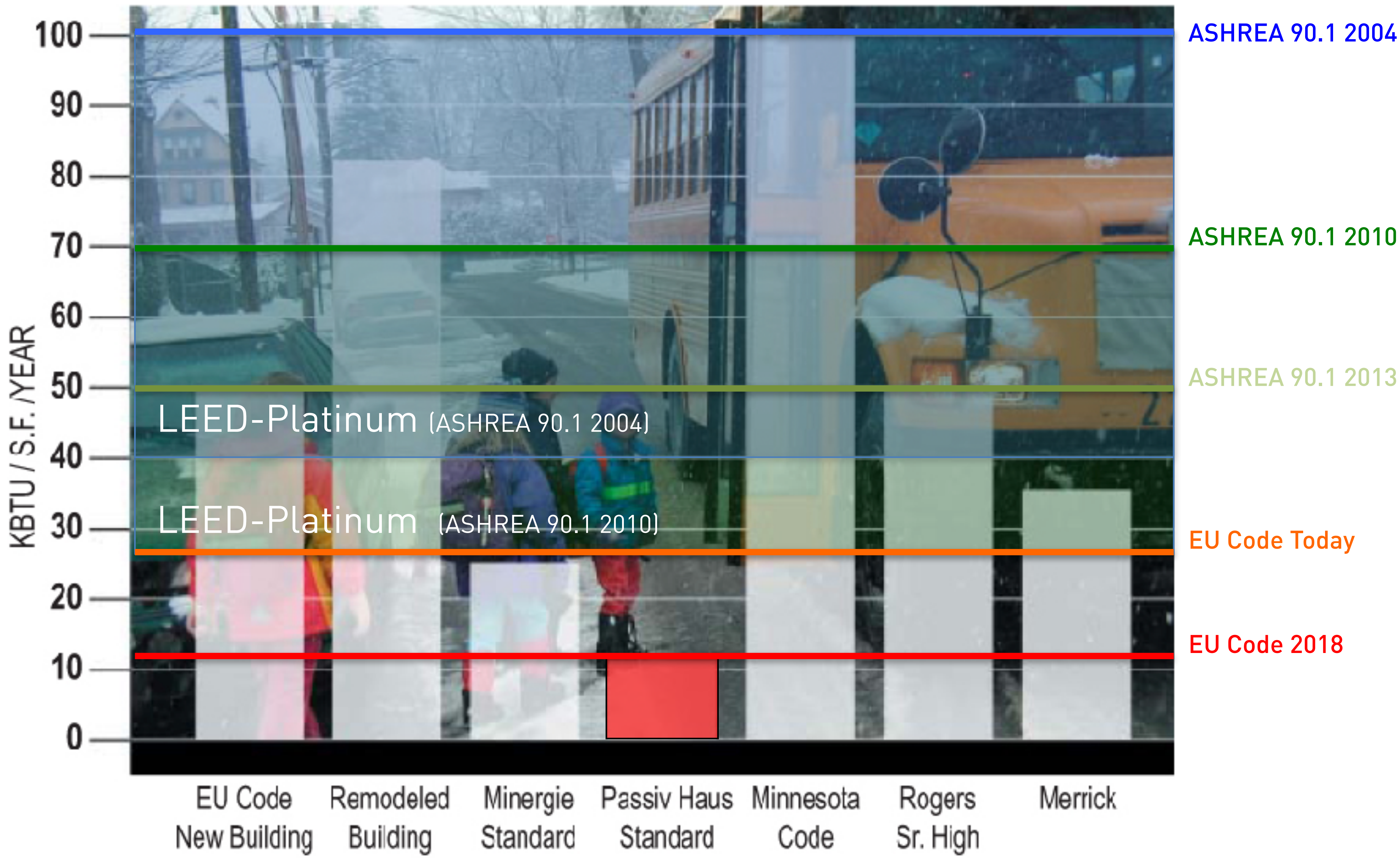
# Performance Comparison

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# Operating a Passive House

Passive House takes care of energy performance. Other systems and certifications are recommended to control:

- Environmentally and people friendly use of resources
- Operation, facility management
- Indoor environmental quality

# Key Conclusions & Benefits

- It just works
- No need for very sophisticated or complicated systems
- Indoor environmental quality is fantastic
- Energy performance is stellar and consistent

# Case Study 2

## State of South Dakota

Pierre, SD - 2012/14

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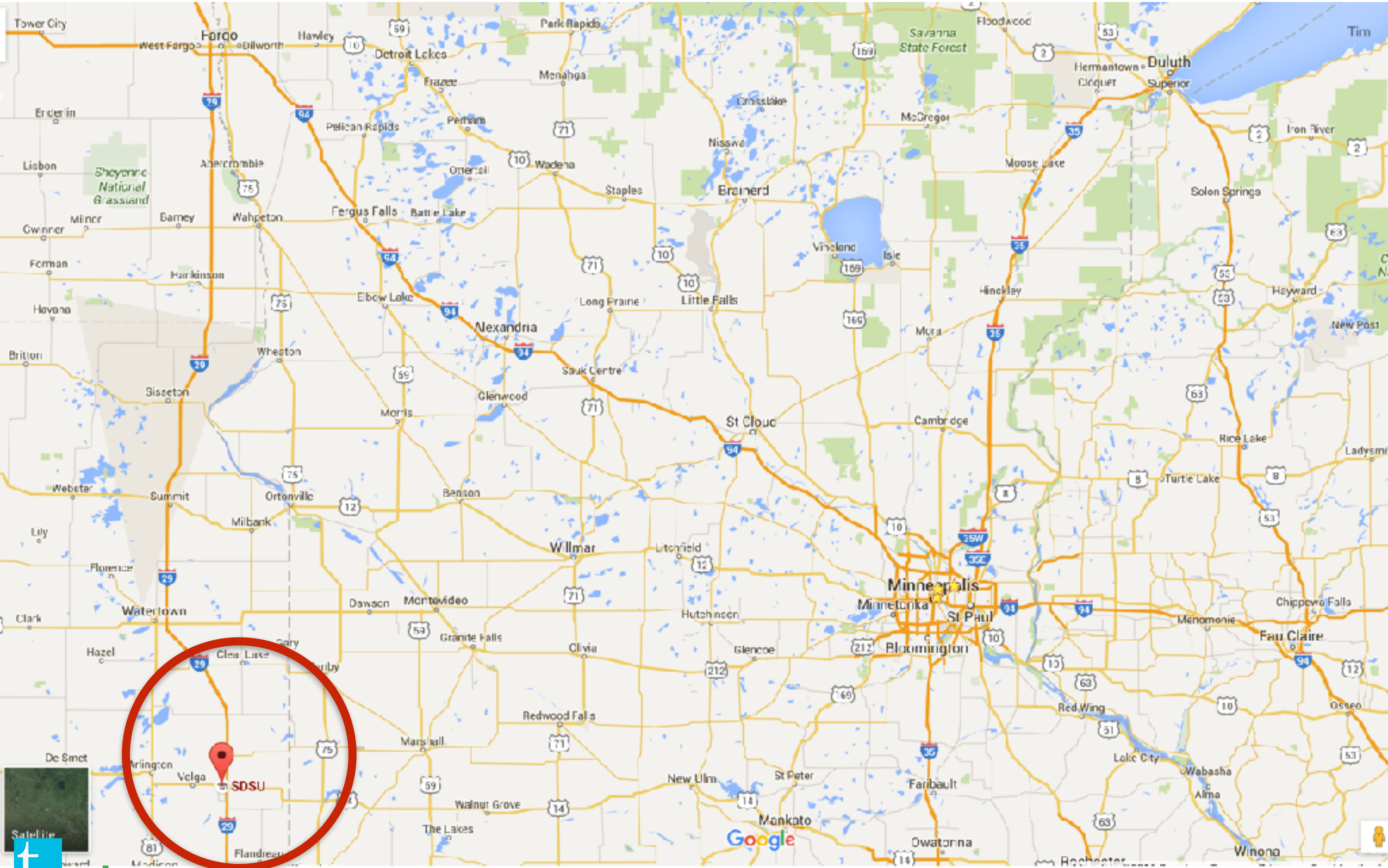
# Project

**Using the Passive House Standard for State projects. What changes?**

- Differences for the Building Envelope
- Thermal Bridge Free Design
- Heat Flow and Loss Comparisons
- Energy Consumption and Flow Comparisons
- Carbon Emissions Comparison
- First Day and Life Cycle Cost Comparison
- Key Conclusion and Benefits

# SDSU, Brookings, South Dakota

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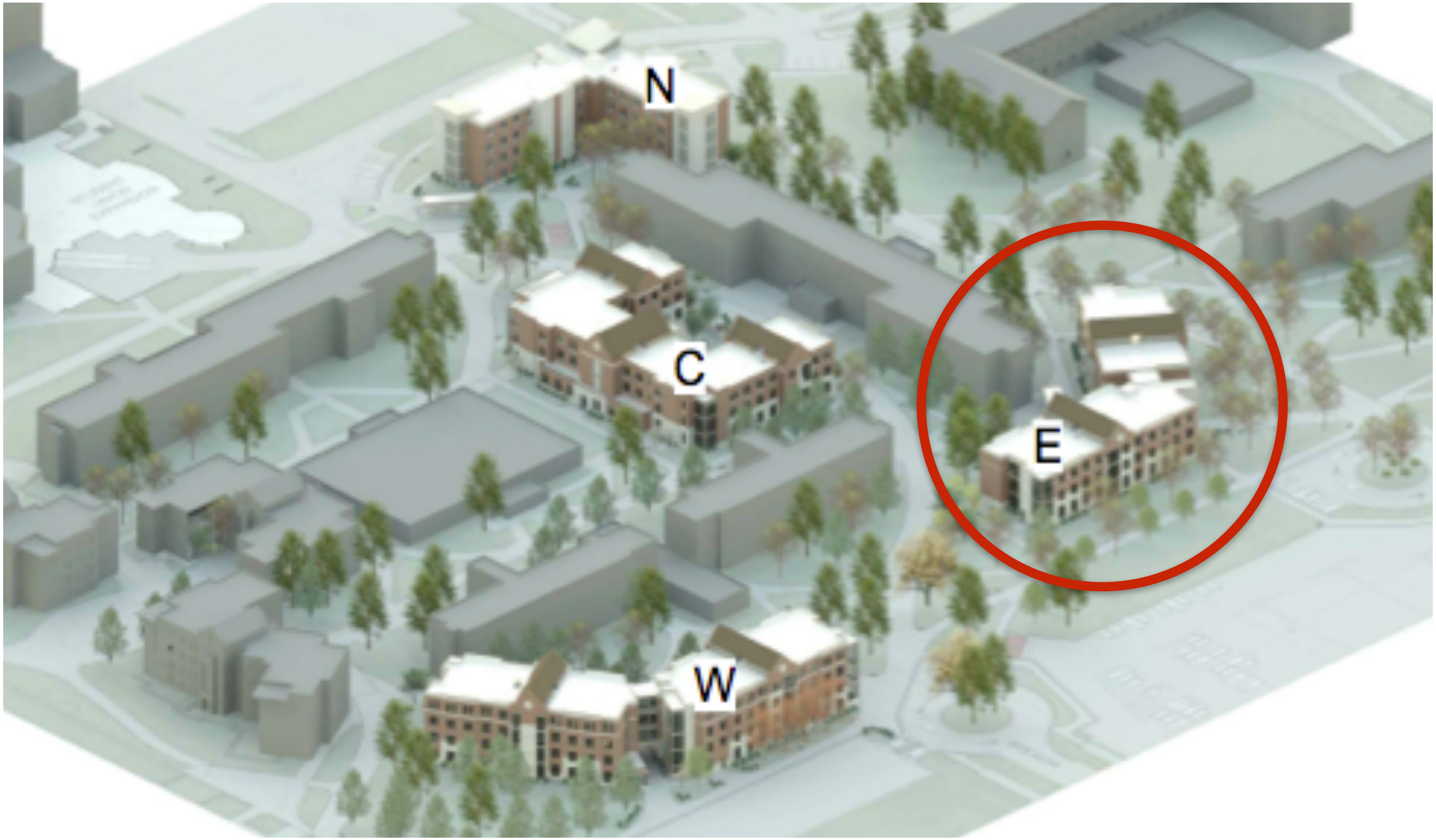
# Jackrabbit Grove Residence Hall




**South Dakota State University campus in Brookings, South Dakota**

**Building E, 2012**

LEED Silver, 95 rooms, 190 tenants

# Jackrabbit Grove Residence Hall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# High-Performance Building Envelope

| | Base Building | Passive House Building |
|---|---|---|
| Exterior Walls | R-16 (h sf °F/ Btu) | **R-34 (h sf °F/ Btu)** |
| Roof | R-70 (h sf °F/ Btu) | R-70 (h sf °F/ Btu) |
| Slab | R-3 (h sf °F/ Btu) | **R-27 (h sf °F/ Btu)** |
| Windows, Ext. Doors | U- 0.41 (Btu/ h sf °F)<br>SHCG-0.27 | **U- 0.12 (Btu/ h sf °F)**<br>**SHCG-0.50** |
| Thermal Bridges | Significant | **Free** |
| Airtightness | $ACH_{50}$: 3.0 1/h (est.) | **$ACH_{50}$: ≤ 0.6 1/h (field tested)** |
| Ventilation w/ HR | 51% HR-Efficiency<br>0.45 Wh/ $m^3$ Electr. Eff. | **87% HR-Efficiency**<br>0.45 Wh/ $m^3$ Electr. Eff. |
| Heating/ Cooling | District heating/cooling | District heating/cooling |

➡ Opportunity for on-site HVAC system

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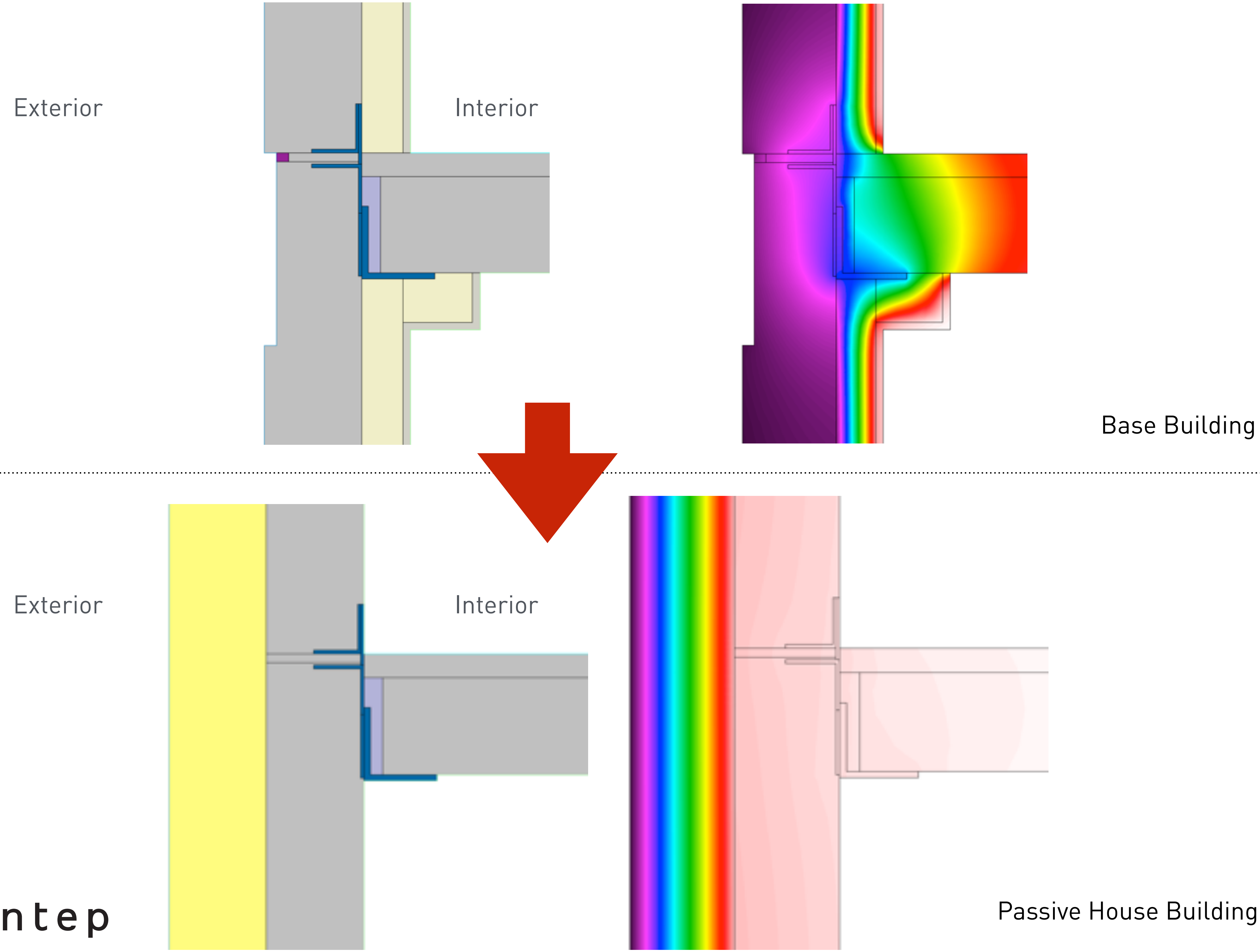
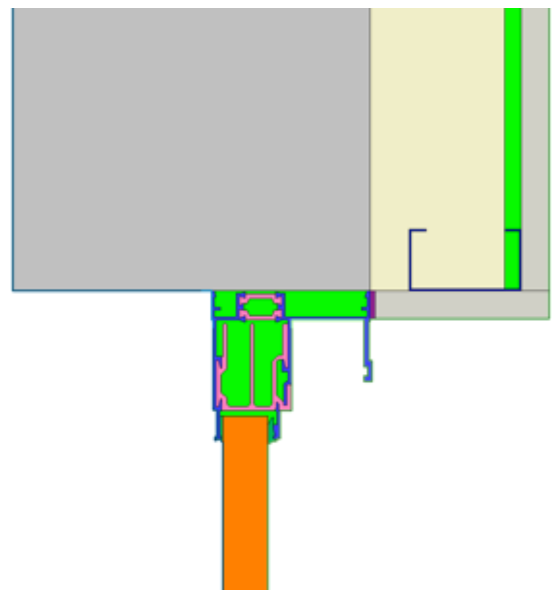
# Thermal Bridge Free Assemblies

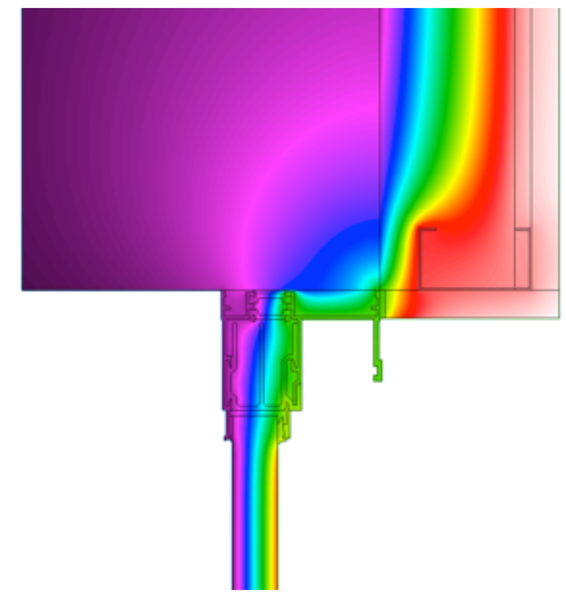


# Thermal Bridge Free Details

Exterior

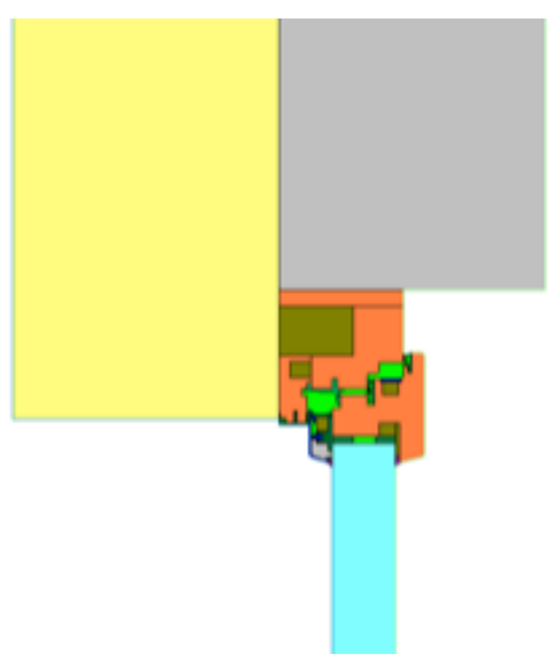


Interior

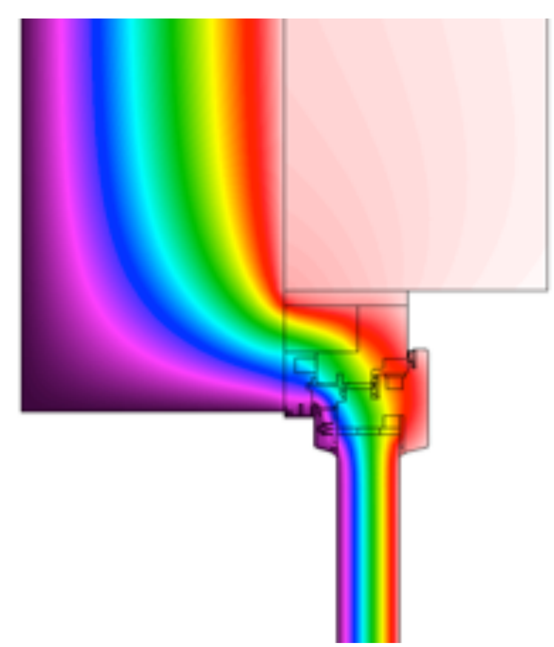


Base Building

Exterior

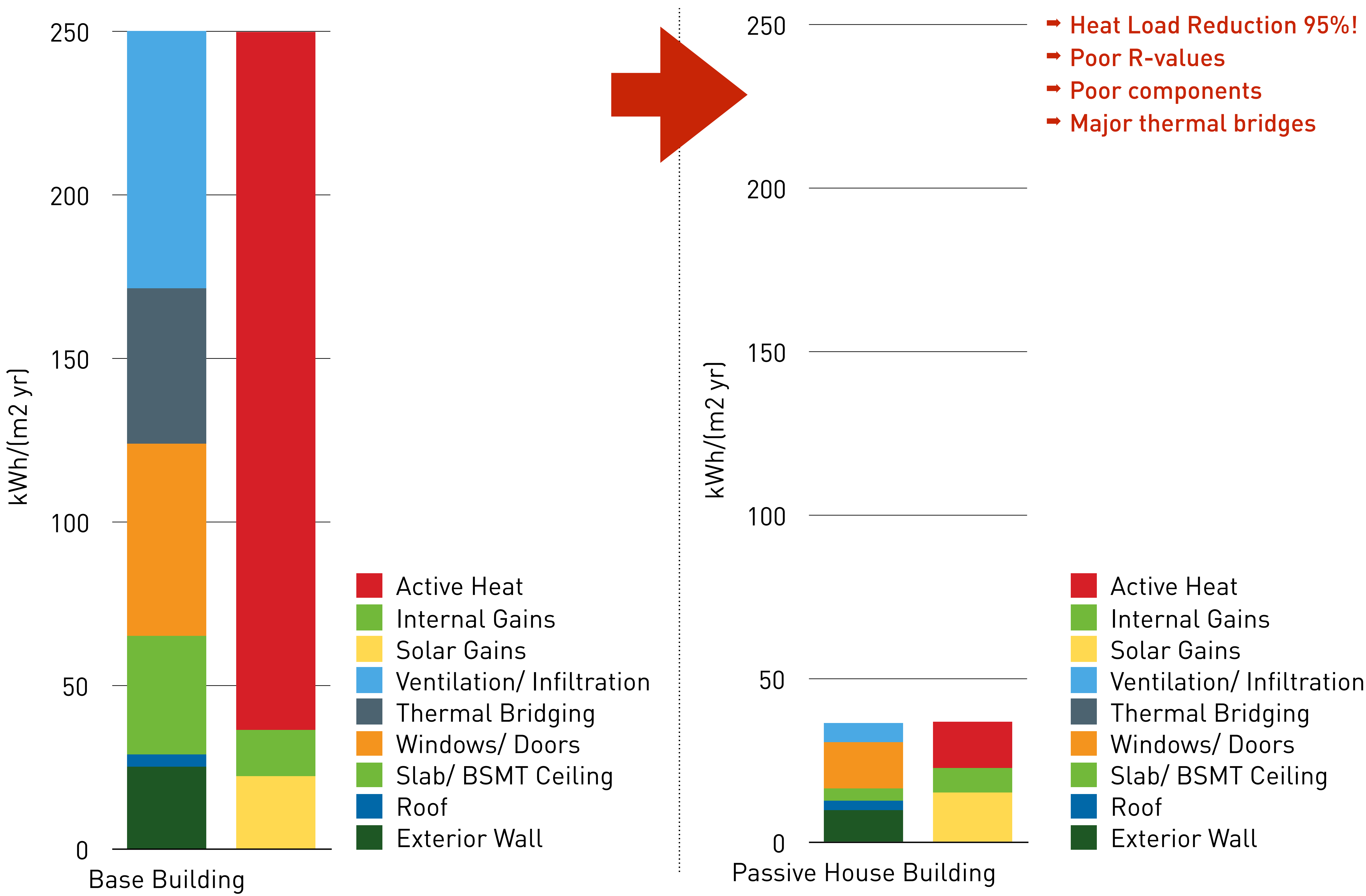


Interior

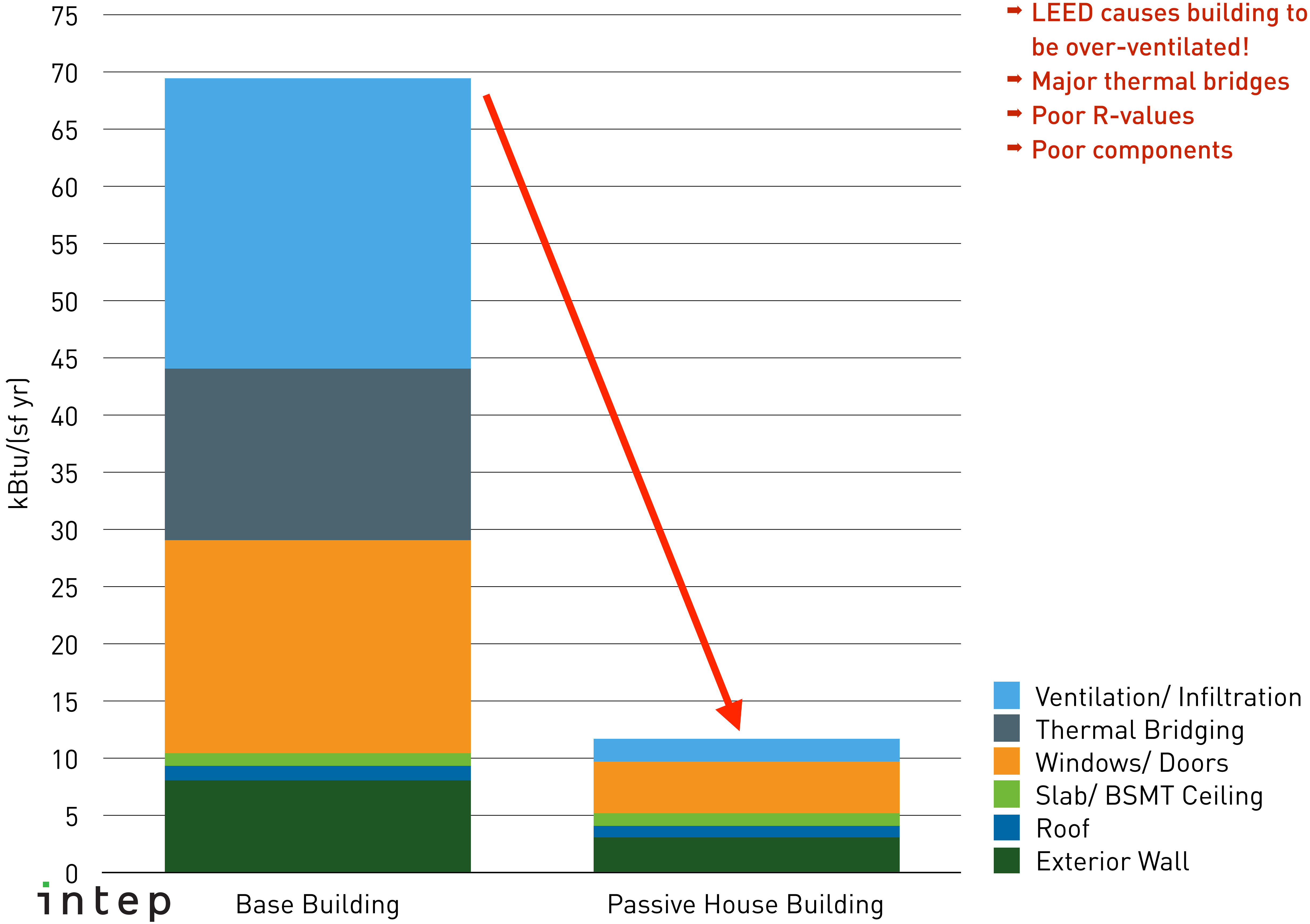


Passive House Building

# Heat Flow Comparison

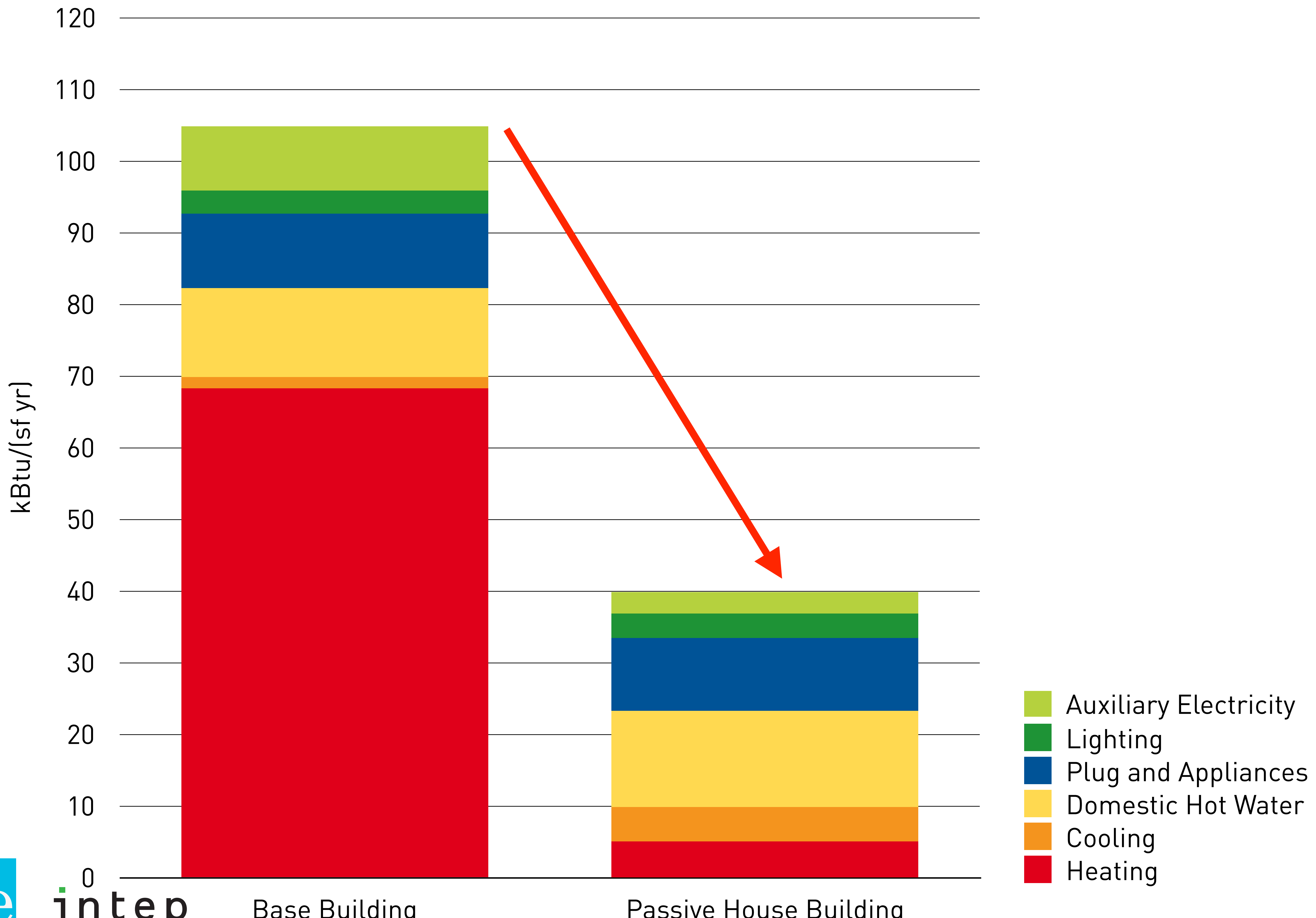


# Heat Loss Comparison

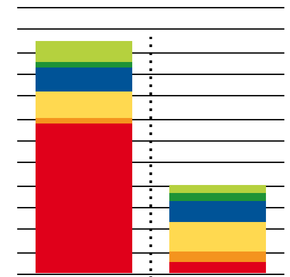



- LEED causes building to be over-ventilated!
- Major thermal bridges
- Poor R-values
- Poor components

# Energy Consumption Comparison

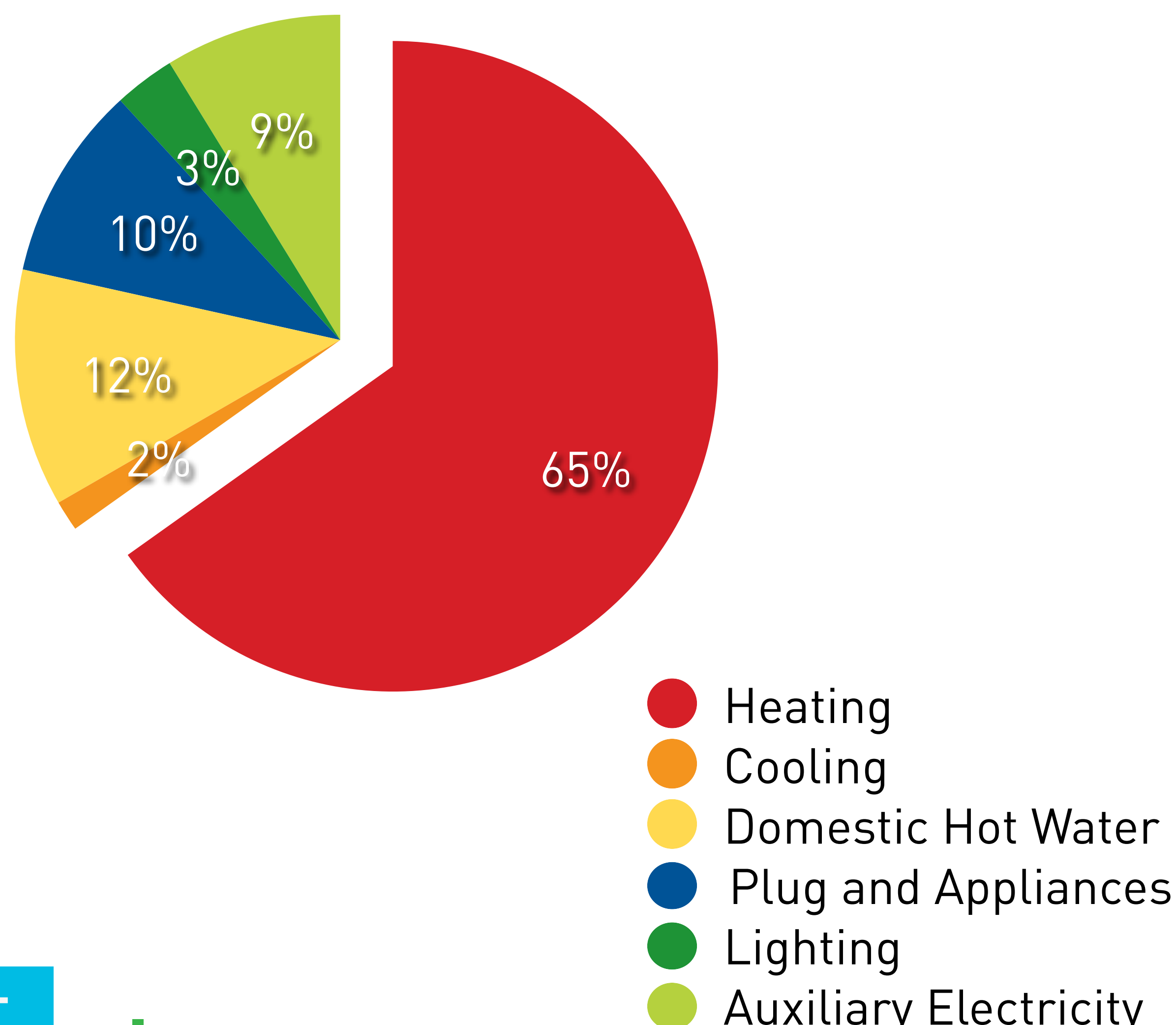


# Energy Flow Comparison

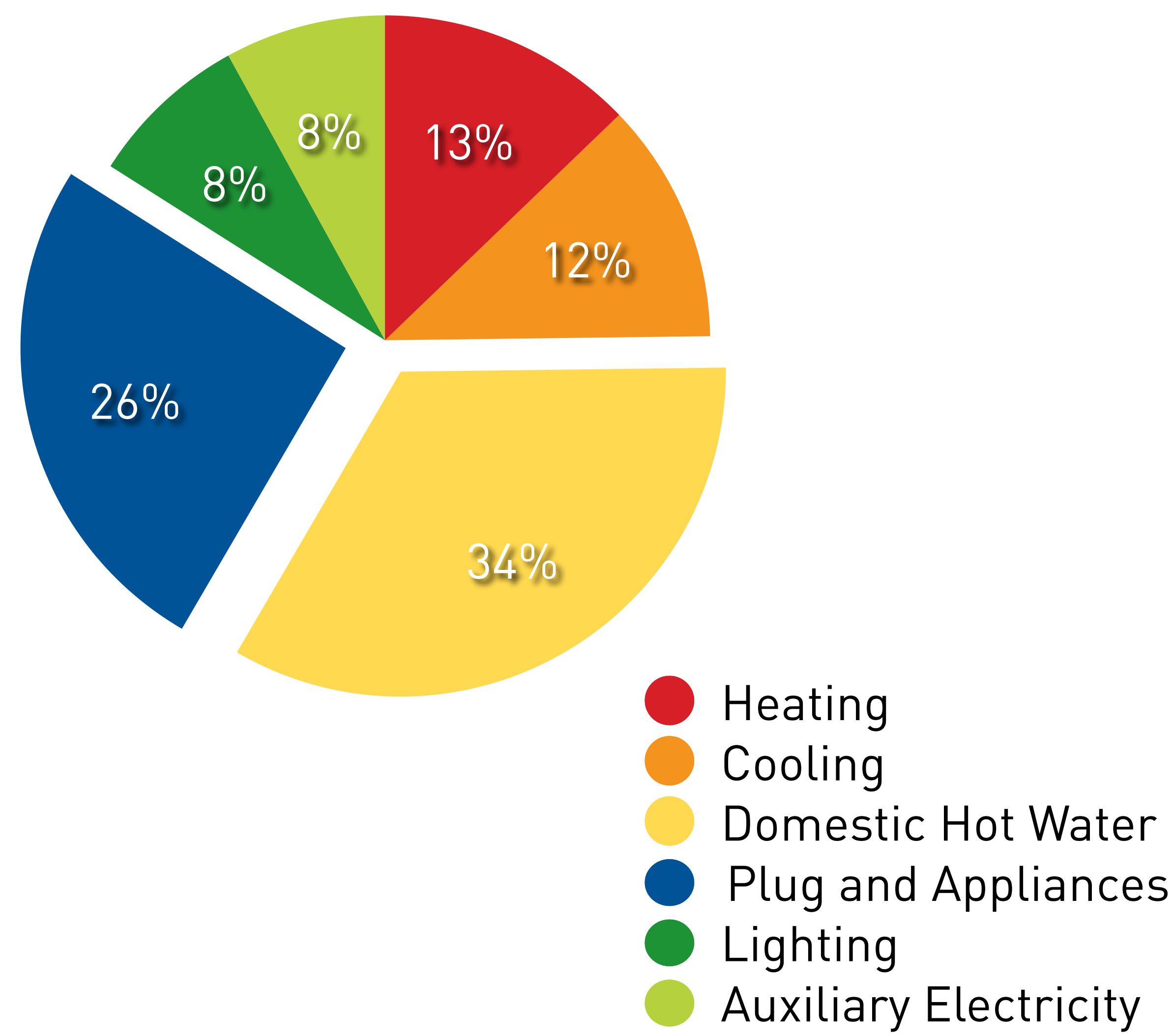


- ➡ Focus on plug loads
- ➡ Focus on domestic hot water

Base Building




Passive House Building

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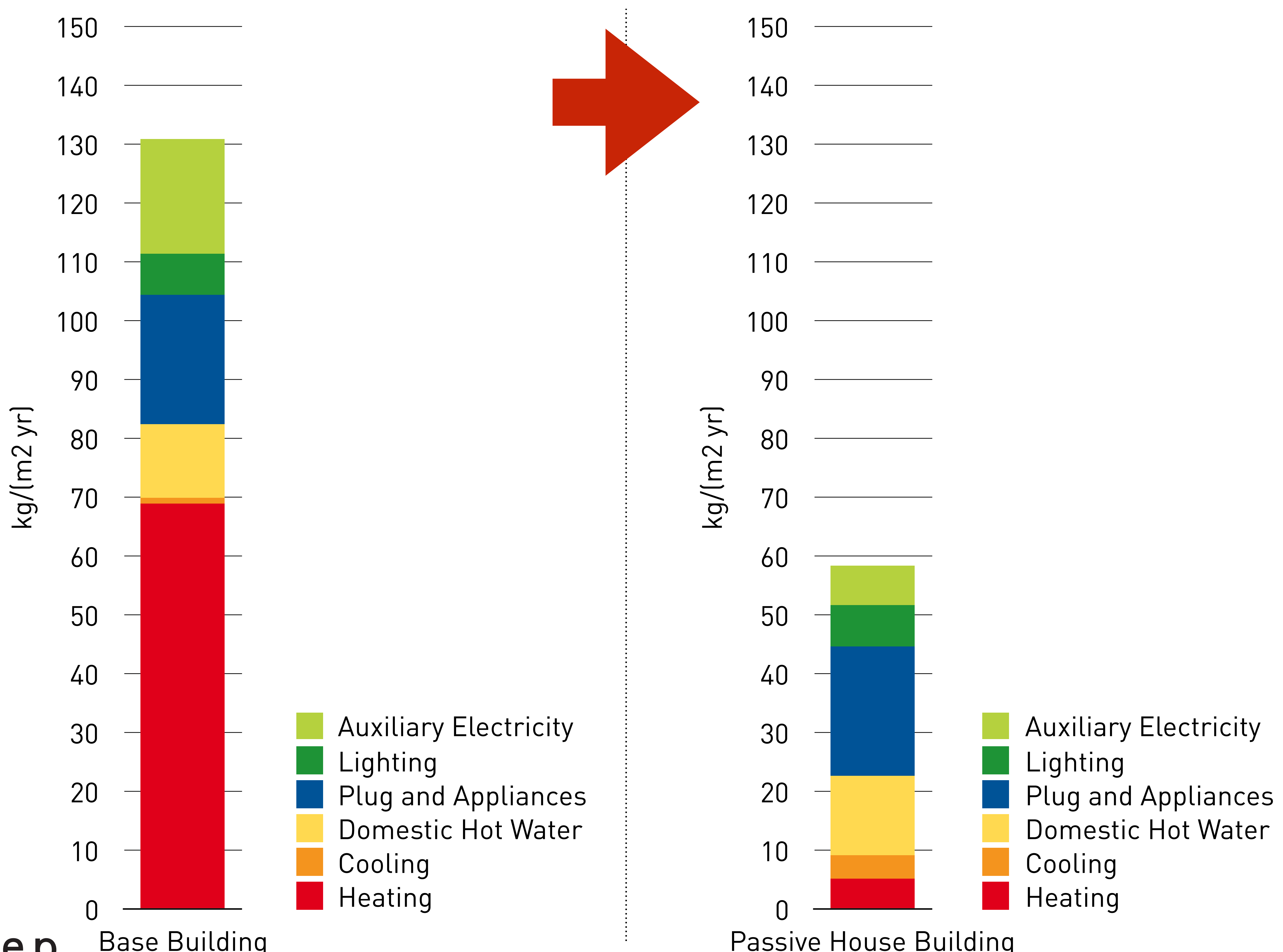
# Carbon Emissions Comparison

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# First Day Cost Comparison

| Building Component | Base Building | Passive House Building | Difference |
|---|---|---|---|
| Structural Building Concrete + Steel + Masonry Systems | $2,015,796 | $2,015,796 | $0 |
| Rough + Finish Carpentry | $230,339 | $230,339 | $0 |
| Roofing, Moisture & Thermal Protection | $334,957 | +$634,957 | +$300,000 |
| Glass & Glazing/ Door + Hardware | $611,076 | +$1,067,076 | +$456,000 |
| Drywall Steel Stud Framing | $587,489 | $587,489 | $0 |
| Interior Finishes | $451,441 | $451,441 | $0 |
| Specialties & Accessories | $84,406 | $84,406 | $0 |
| Elevators | $95,000 | $95,000 | $0 |
| Plumbing Systems + Fire Suppressions System | $762,800 | $762,800 | $0 |
| HVAC Systems | $518,650 | $468,650 | ($50,000) |
| Electrical Systems | $683,675 | $683,675 | $0 |
| Earthwork Excavation | $122,590 | $122,590 | $0 |
| **Building Investment Cost Total** | **$6,498,219** | **$7,196,046** | **$697,827** |

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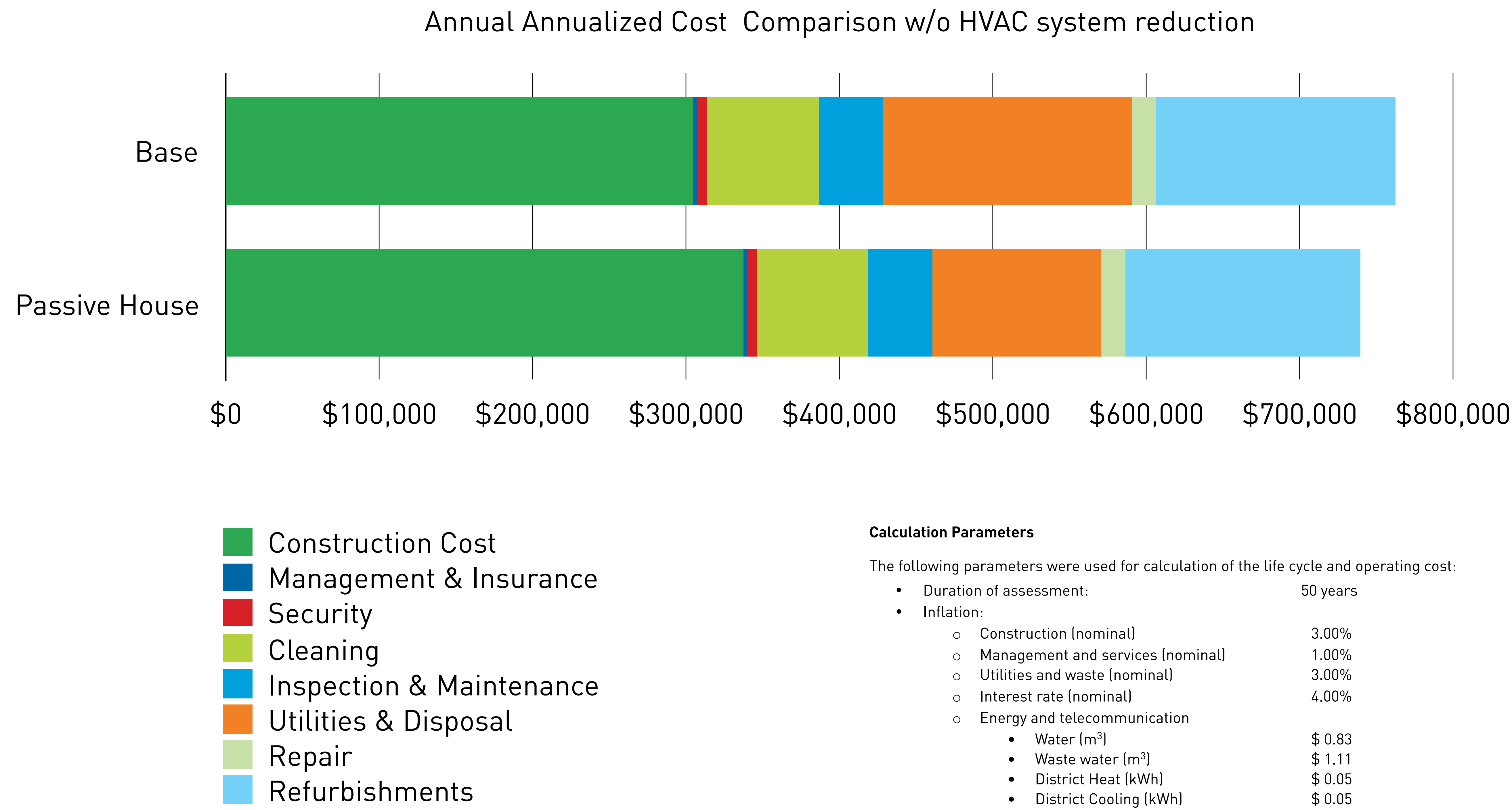
➡ Construction cost increase of approx. 10.5%

# Life Cycle Cost Comparison




**Calculation Parameters**

The following parameters were used for calculation of the life cycle and operating cost:

- Duration of assessment: 50 years
- Inflation:
  - Construction (nominal) 3.00%
  - Management and services (nominal) 1.00%
  - Utilities and waste (nominal) 3.00%
  - Interest rate (nominal) 4.00%
  - Energy and telecommunication
    - Water ($m^3$) $ 0.83
    - Waste water ($m^3$) $ 1.11
    - District Heat (kWh) $ 0.05
    - District Cooling (kWh) $ 0.05
    - Electricity (kWh) $ 0.07

➡ Annual Annuitized Cost Reduction of approx. 3%

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# Key Conclusions & Benefits

- Passive House costs less over its life
  (annuitized and total cost of ownership)
- Construction cost increase; approx. 10.5%
  (mostly building envelope) **(HVAC system savings are not accounted for in this study)**
- Operating cost decrease; annuitized annual cost decrease approx. 3%
  (mostly utilities and refurbishments)
- Improved financial risk management
  (predictable and lower life cycle cost)
- Increased competitiveness and resilience
  (improved bottom line, simpler systems, less reliance on HVAC)
- Increased quality of the building and reduced risk for early building deterioration
  (field testing and thermal bridge free design)
- Comfort improvement
  (Happier and healthier tenants = less call-backs)
- Carbon risk management and premier environmental stewardship

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# Case Study 3

## Hongqiao Lvyuan Passive House Retrofit

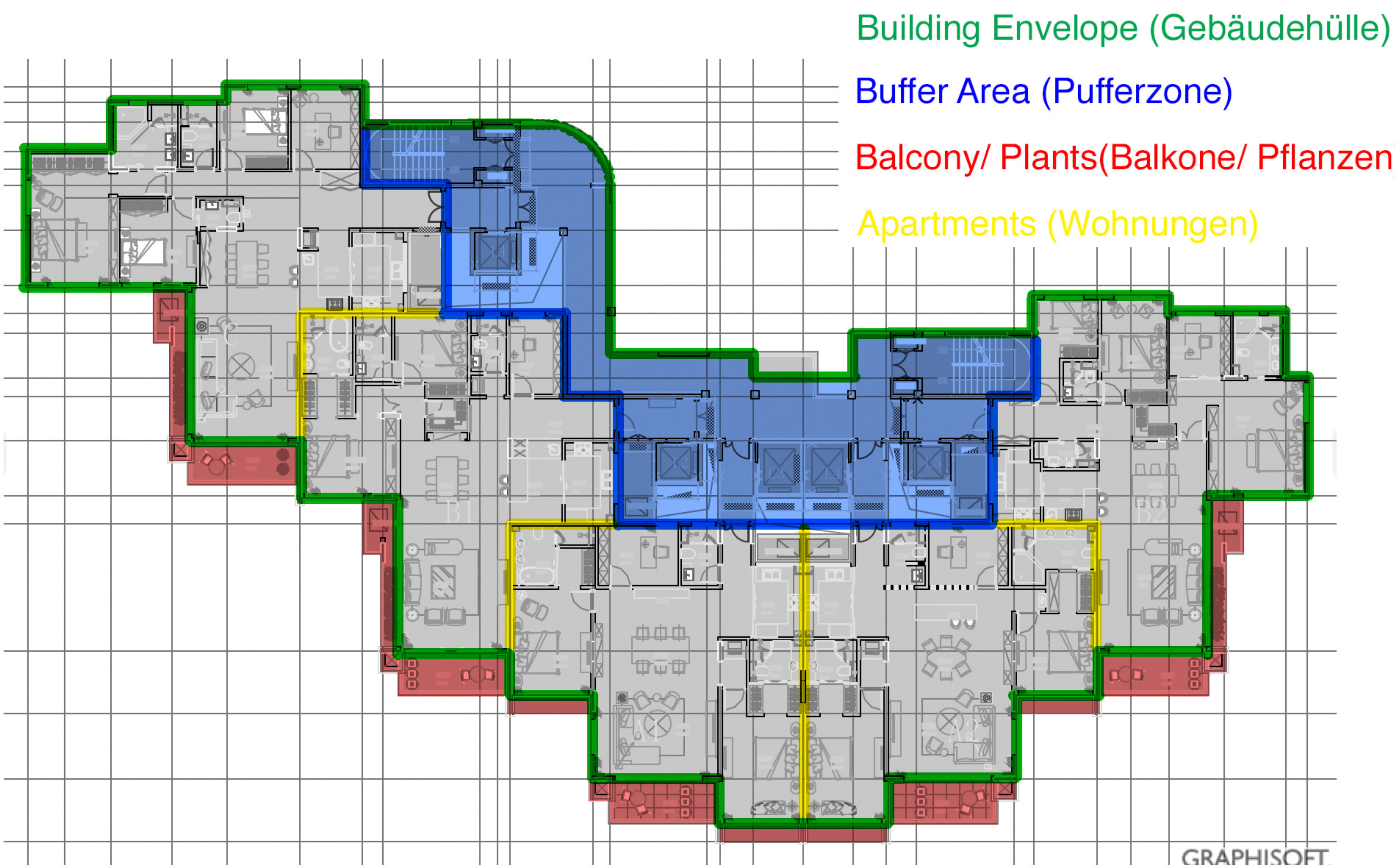
Shanghai, China - 2015/17

# Project

**First Passive House Retrofit (EnerPHit) in Shanghai. Three, 25-unit condo buildings. 5-stories and 45,000 gross sf ea. Hot and humid climate.**

- Defining the Building Envelope
- Identifying Key Details
- Managing PH-Compliance
- MEP Strategies
- System Opportunities
- Resource Shifting
- Key Conclusion and Benefits

# Defining the Building Envelope

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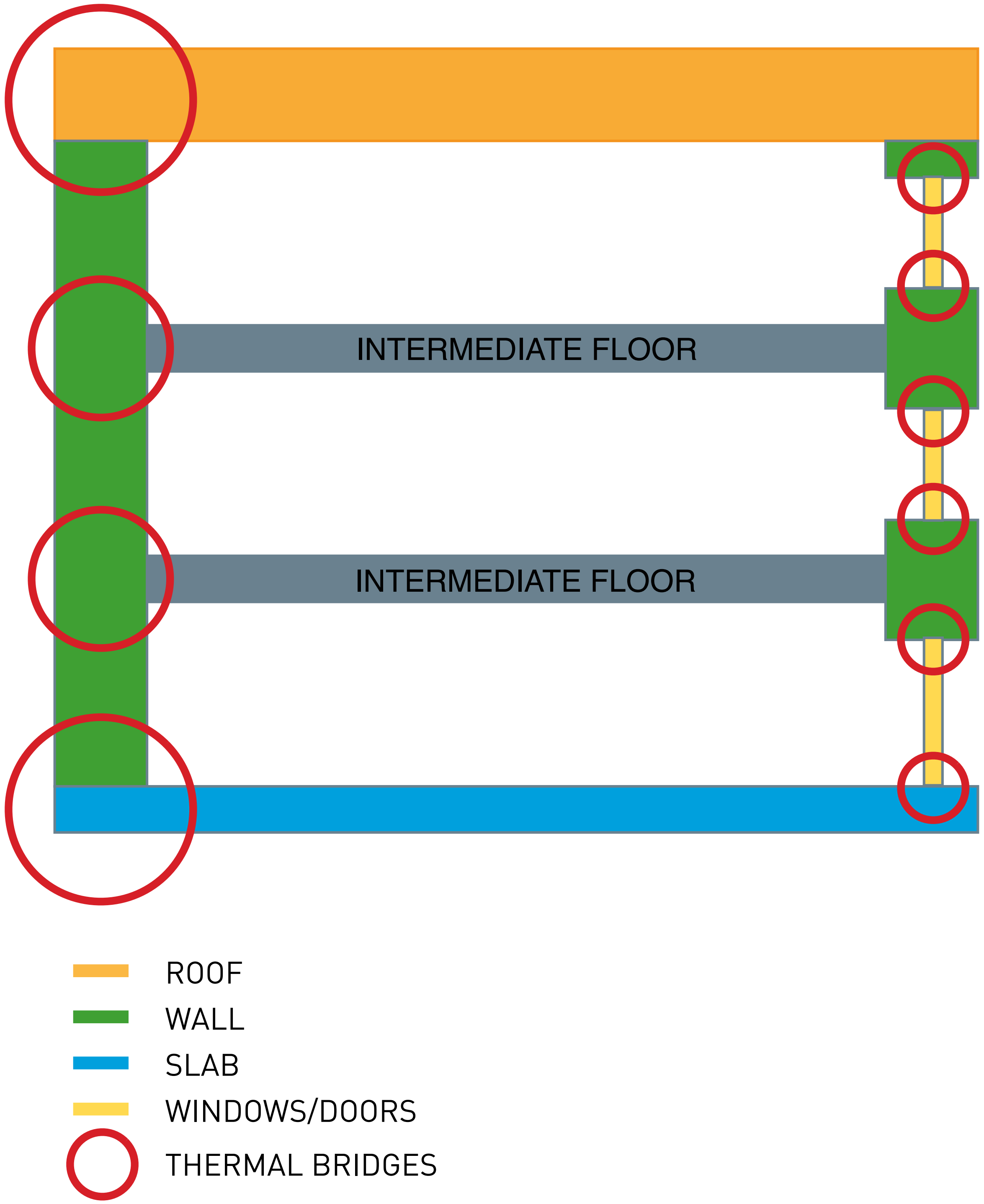
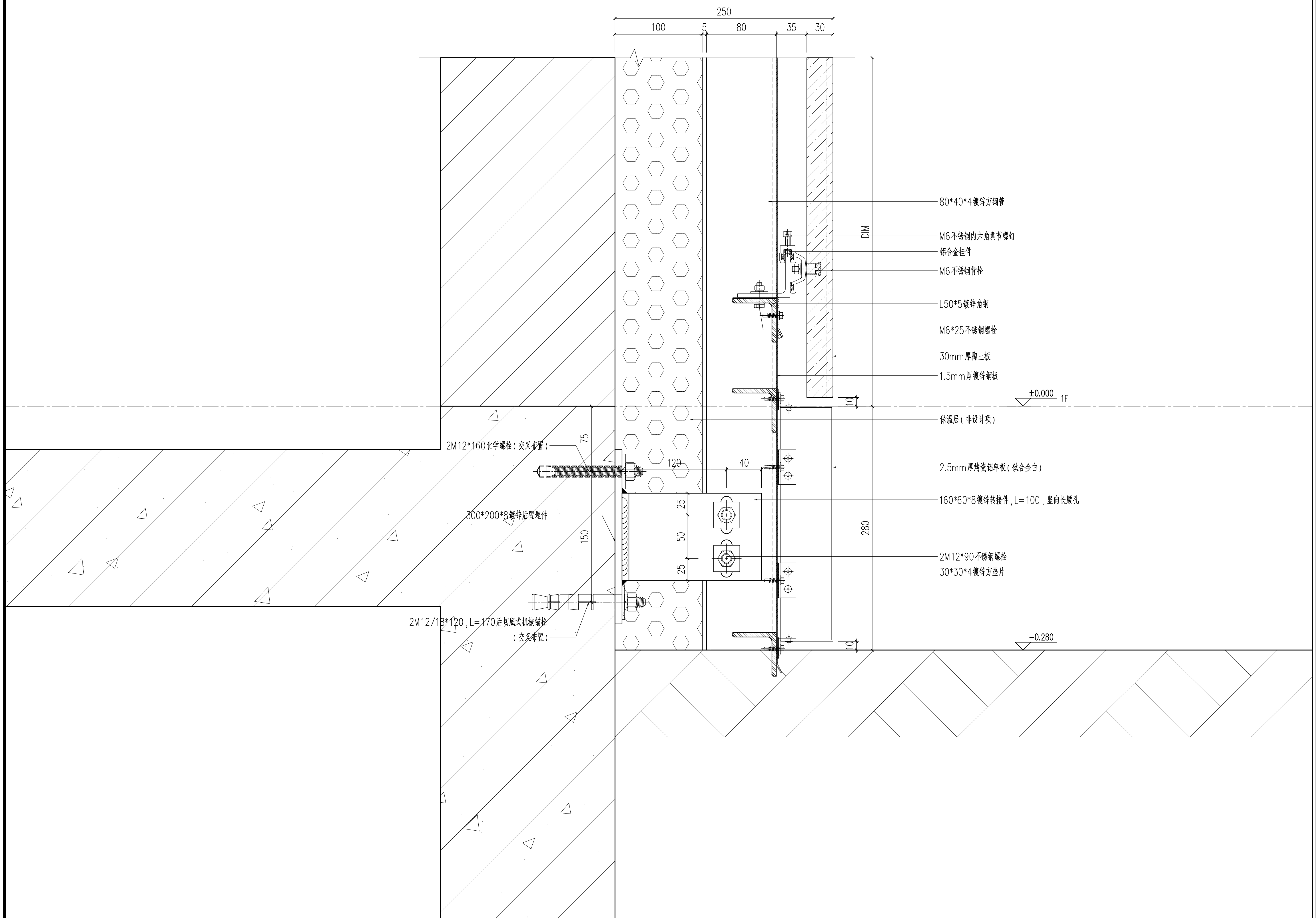
# Identifying Key Details



# Managing PH-Compliance

- Overlay standard details with Passive House details, or design PH right from the beginning
- Clearly outline insulation, airtightness, hygrothermal performance and understand climate influences
- Define strategies, systems and components which support the Passive House targets

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图例：

建筑师：
上海中建建筑设计院有限公司

开发商：
上海亚太国际房地产有限公司

工程名称：
虹桥绿苑外立面改建工程
（1#、2#、3#楼）

图纸名称：
节点图

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| 设计 | 何怡云 |
| 校对 | 钱俊 |
| 审核 | 杨云 |
| 专业负责 | 孙琳 |
| 比例 | 1:3 |
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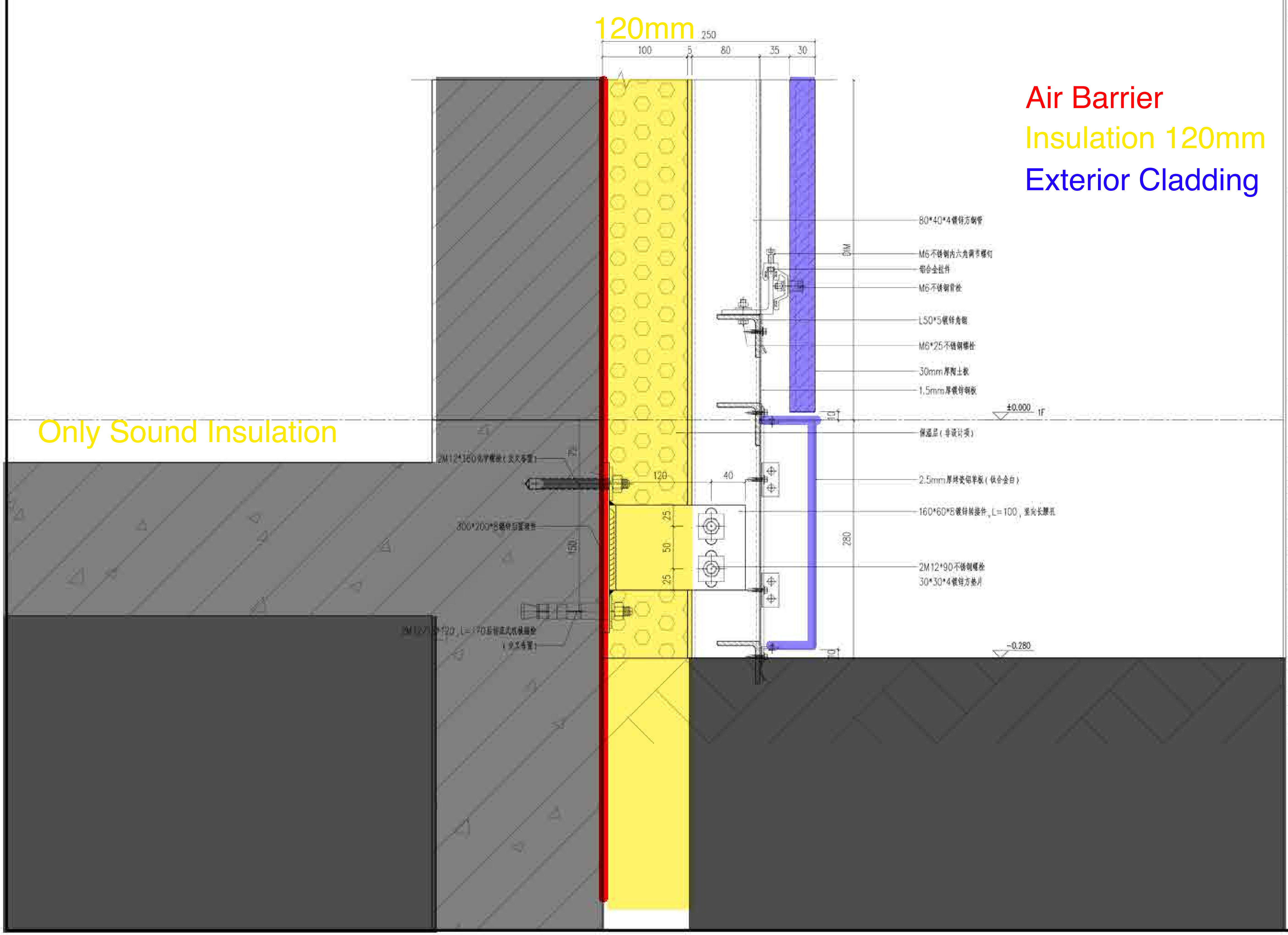


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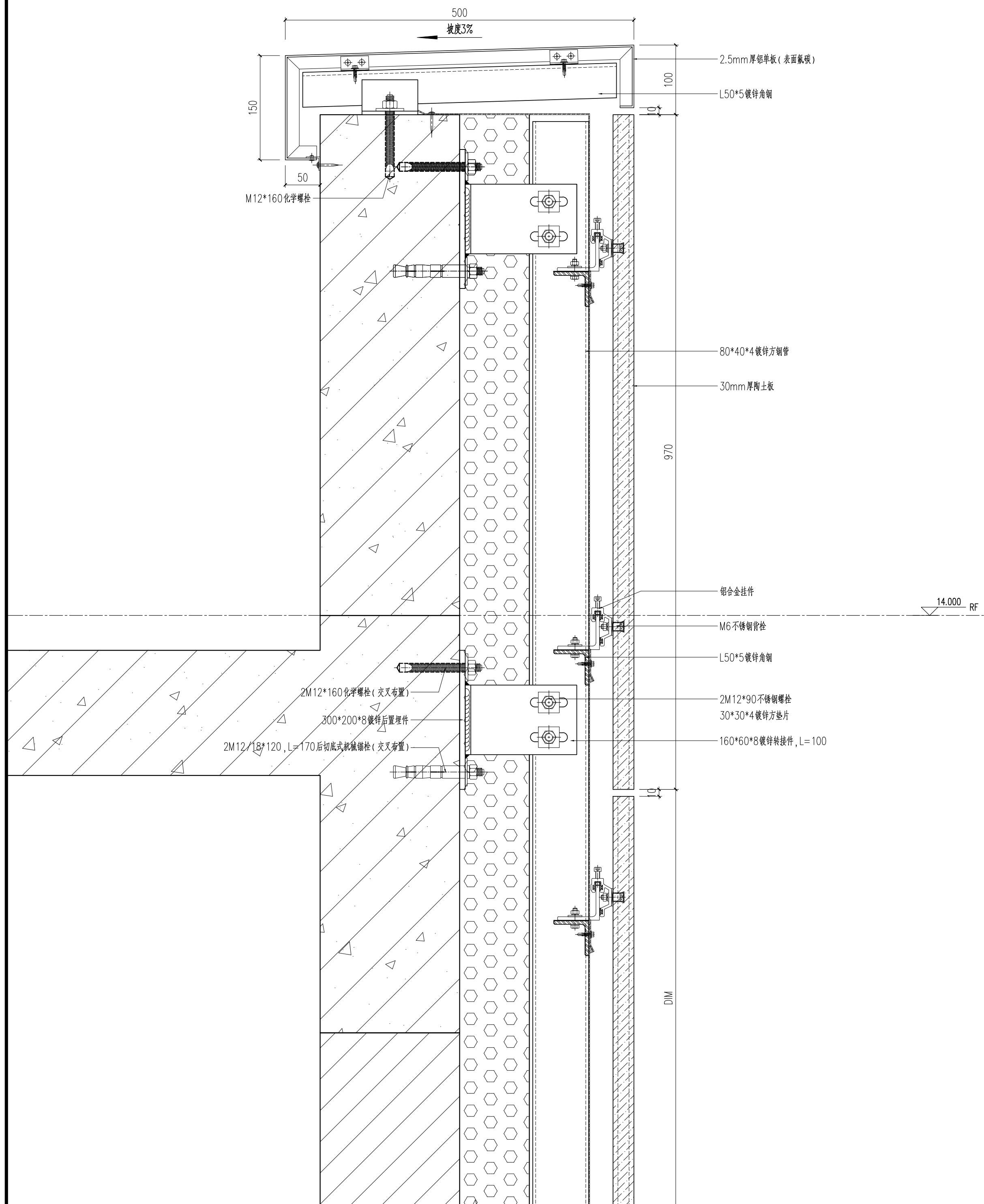


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图例:

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工程名称: 虹桥绿苑外立面改建工程(1#、2#、3#楼)

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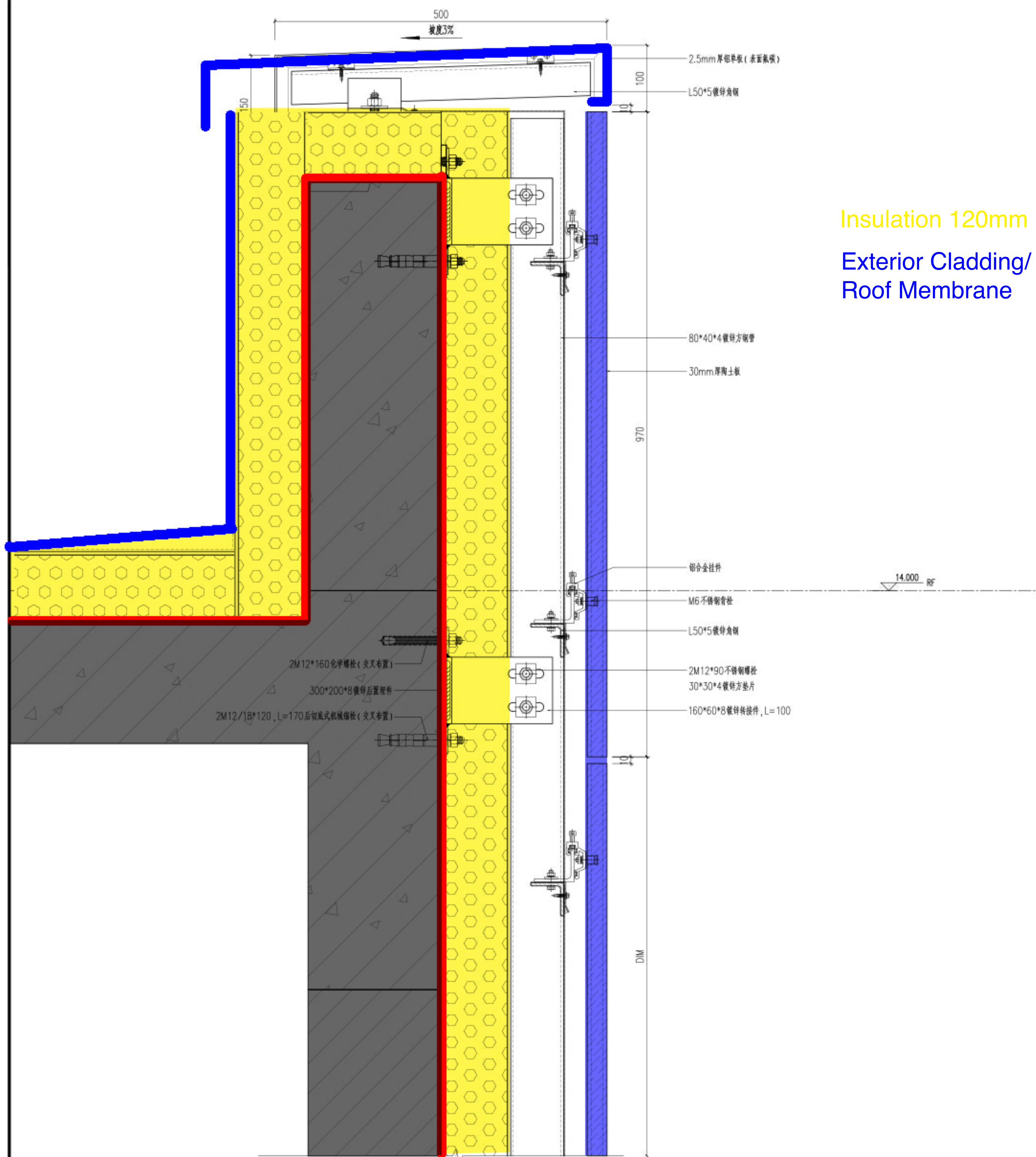


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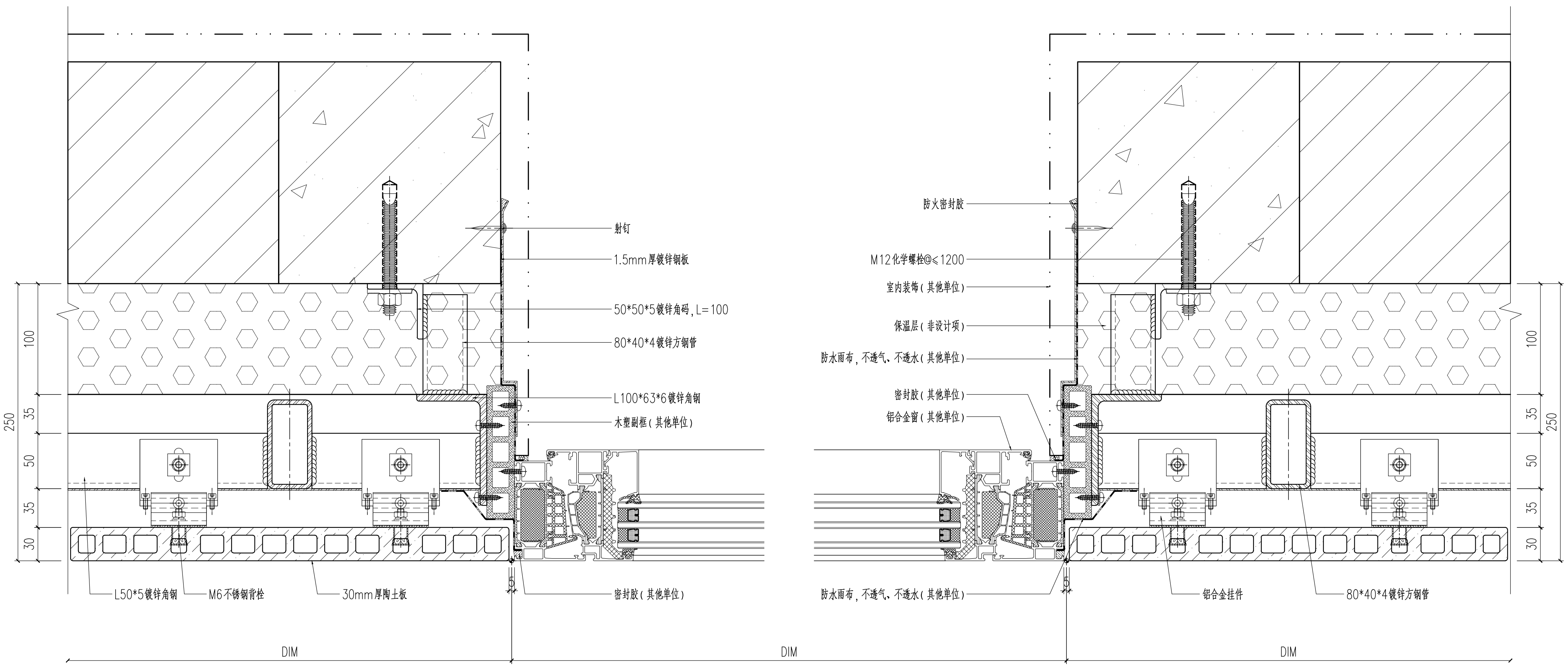


YUAN TAI

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图例：

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上海中建建筑设计院有限公司

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| 专业负责 | 沈琳 |
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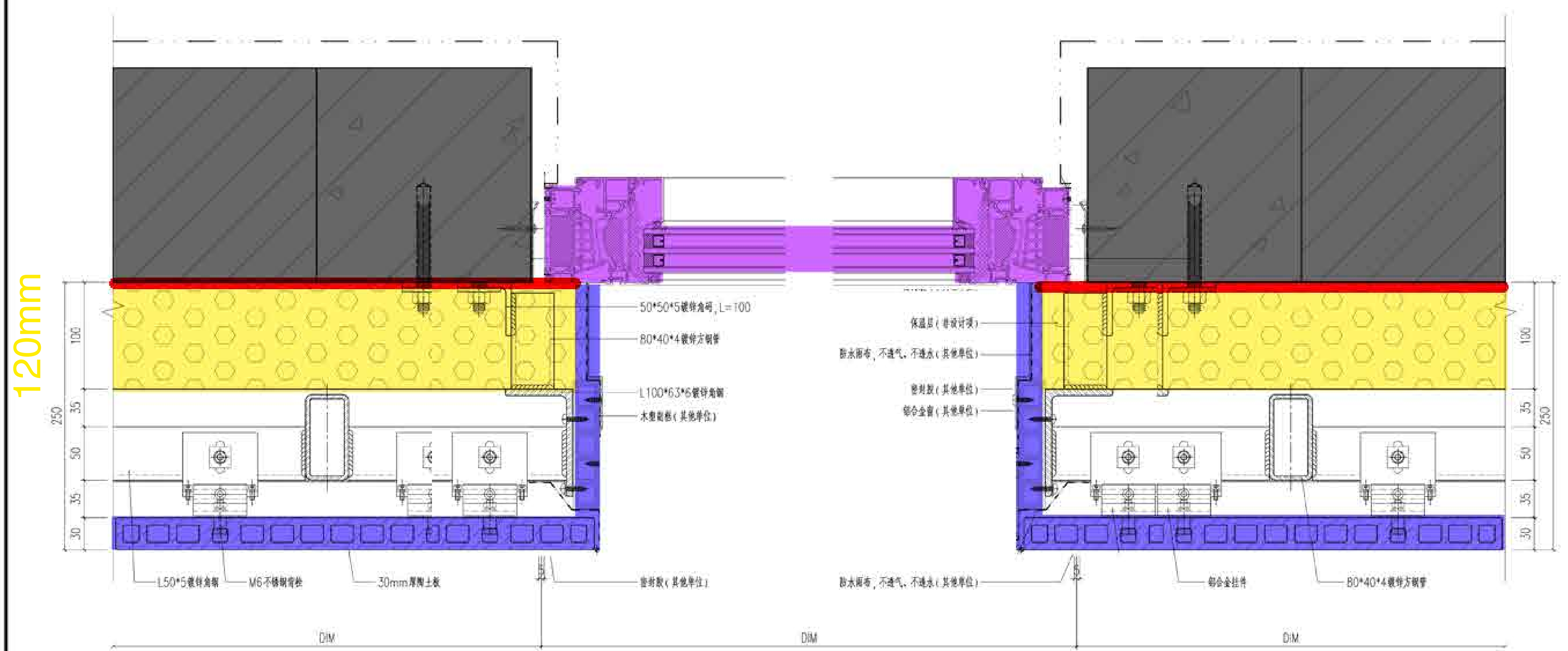


Window/ Door

Air Barrier

Insulation 120mm

Exterior Cladding

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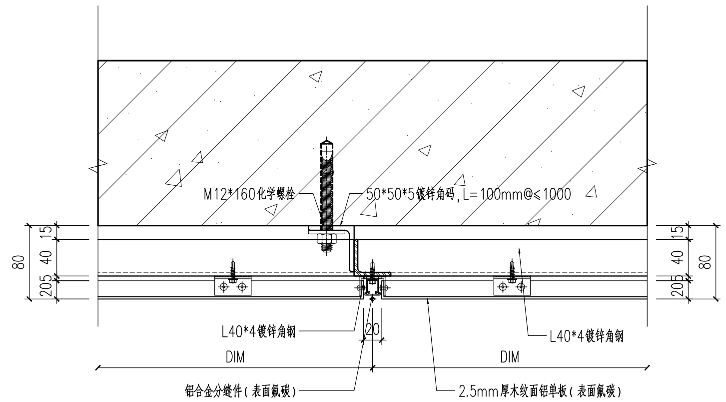
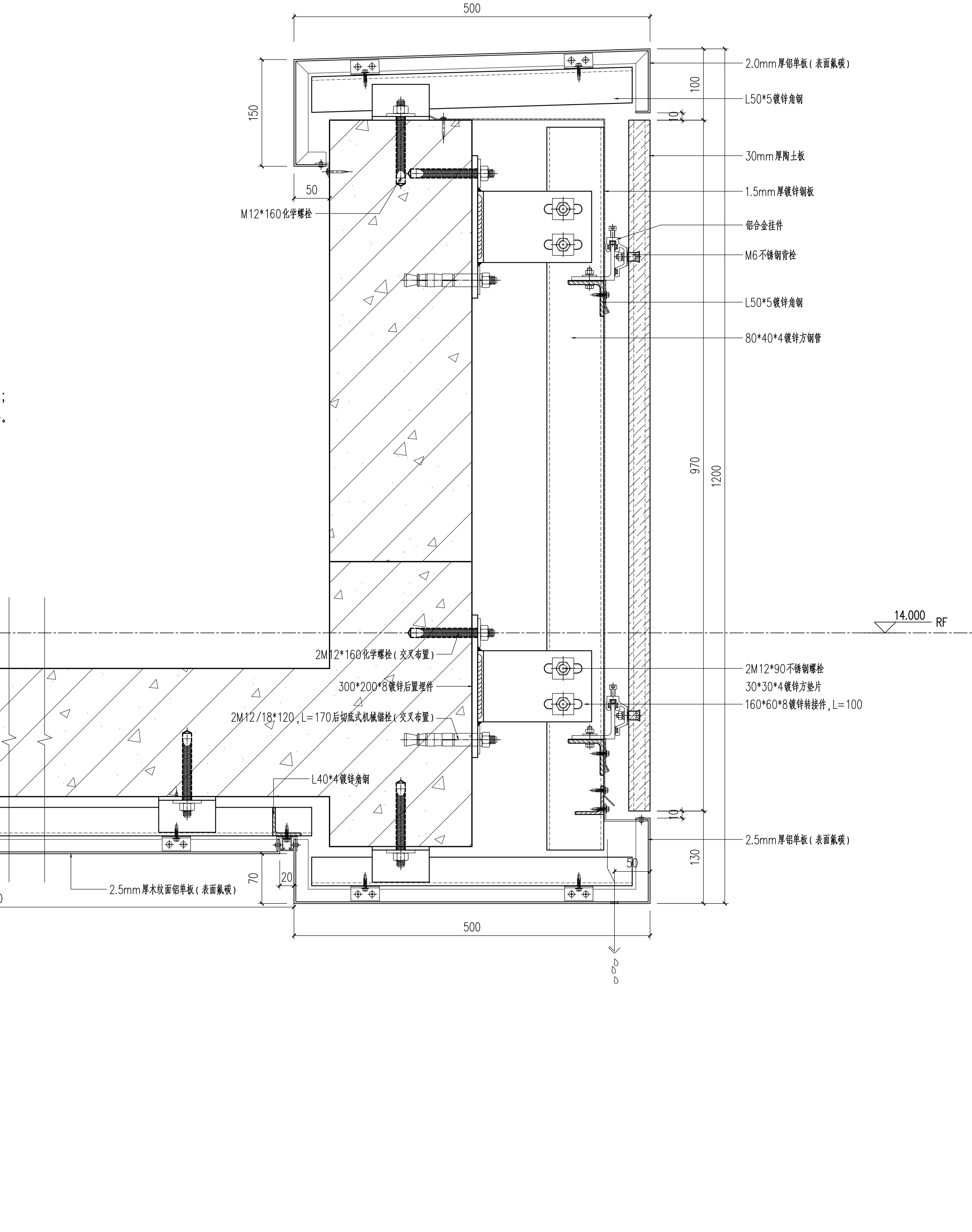
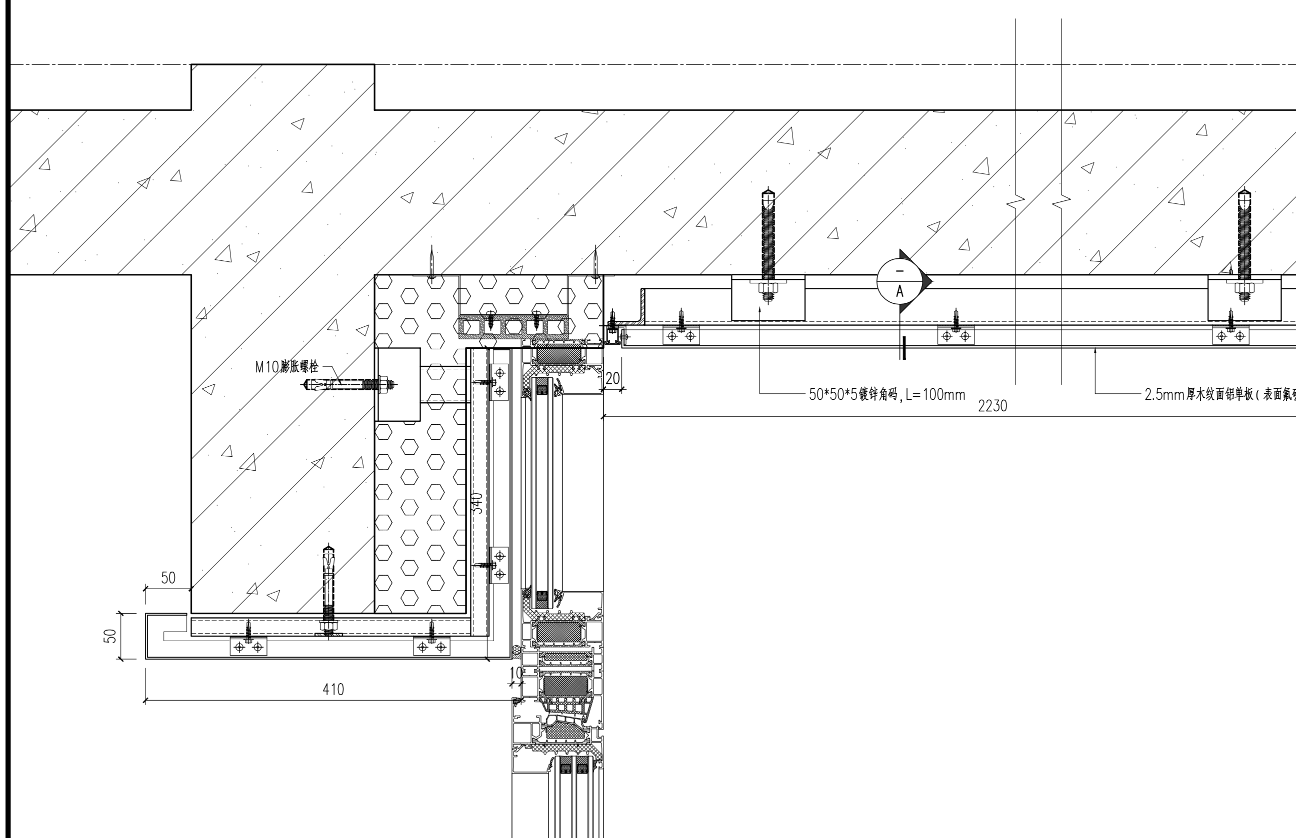



A 节点图 SCALE 1:5

说明：
1.所有铝板吊顶做法均按照本节点图；
2.竖向分格缝处，均有铝合金分缝件。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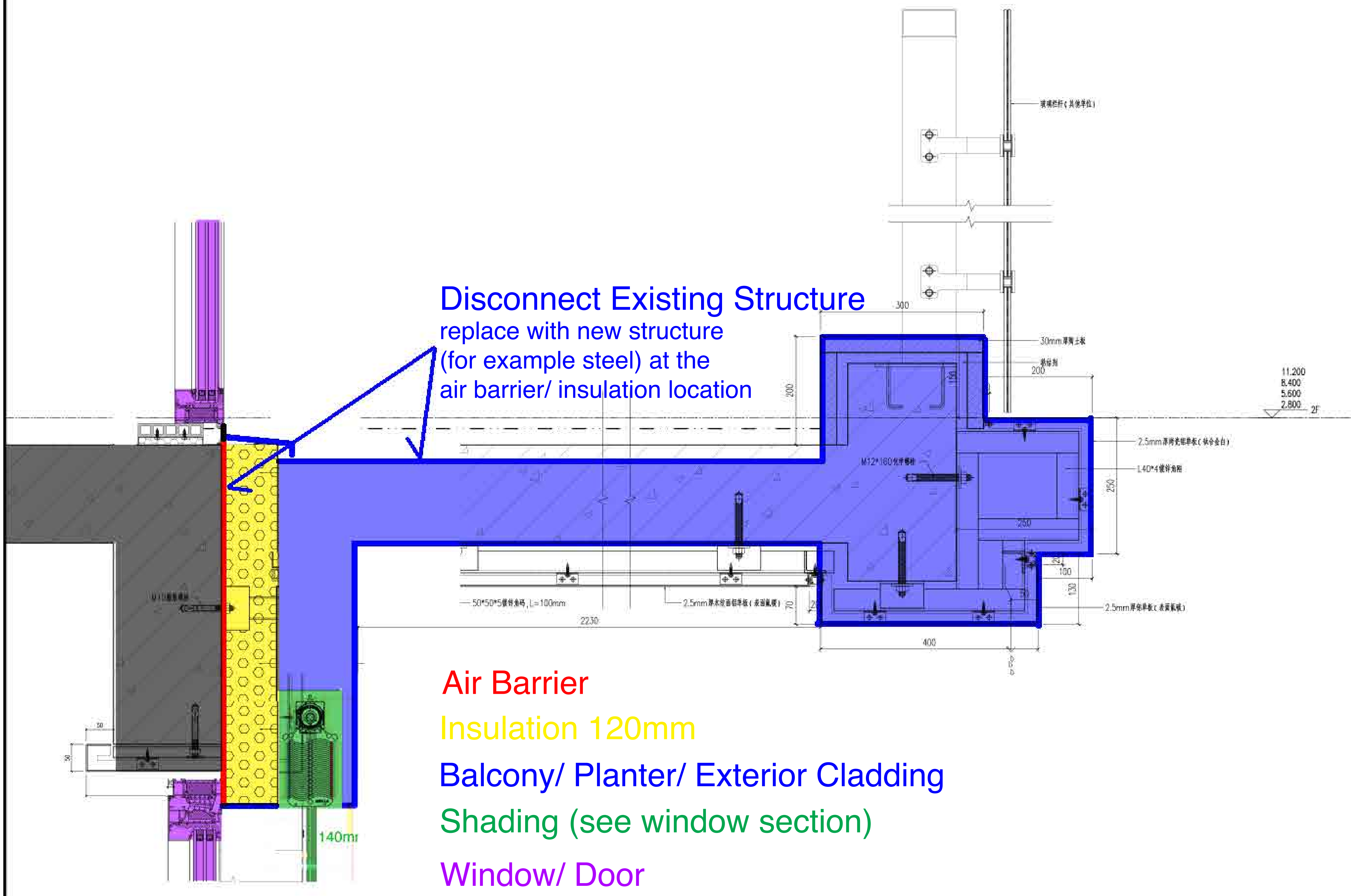
| 中建远泰幕墙装饰工程有限公司 ZHONGJIAN YUANTAI WALL DECRATION ENGINEERING CO.,LTD. | |
| 图例： | |
| 建筑师： | 上海中建建筑设计院有限公司 |
| 开发商： | 上海亚太国际房地产有限公司 |
| 工程名称： | 虹桥绿苑外立面改建工程（1#、2#、3#楼） |
| 图纸名称： | 节点图 |
| 设　计 | 何怡云 |
| 校　对 | 钱俊 |
| 审　核 | 杨訁 |
| 专业负责 | 沈耕 |
| 比　例 | 1:5 |
| 图　号 | JD-14 |
| 图　幅 | A2 |
| 专　业 | 幕墙 |
| 版　号 | A |
| 阶　段 | 施工图 |
| 工程编号 | |
| 出图签章： | |




中建远泰幕墙装饰工程有限公司
ZHONGJIAN YUANTAI WALL
DECRATION ENGINEERING CO., LTD.

图例:

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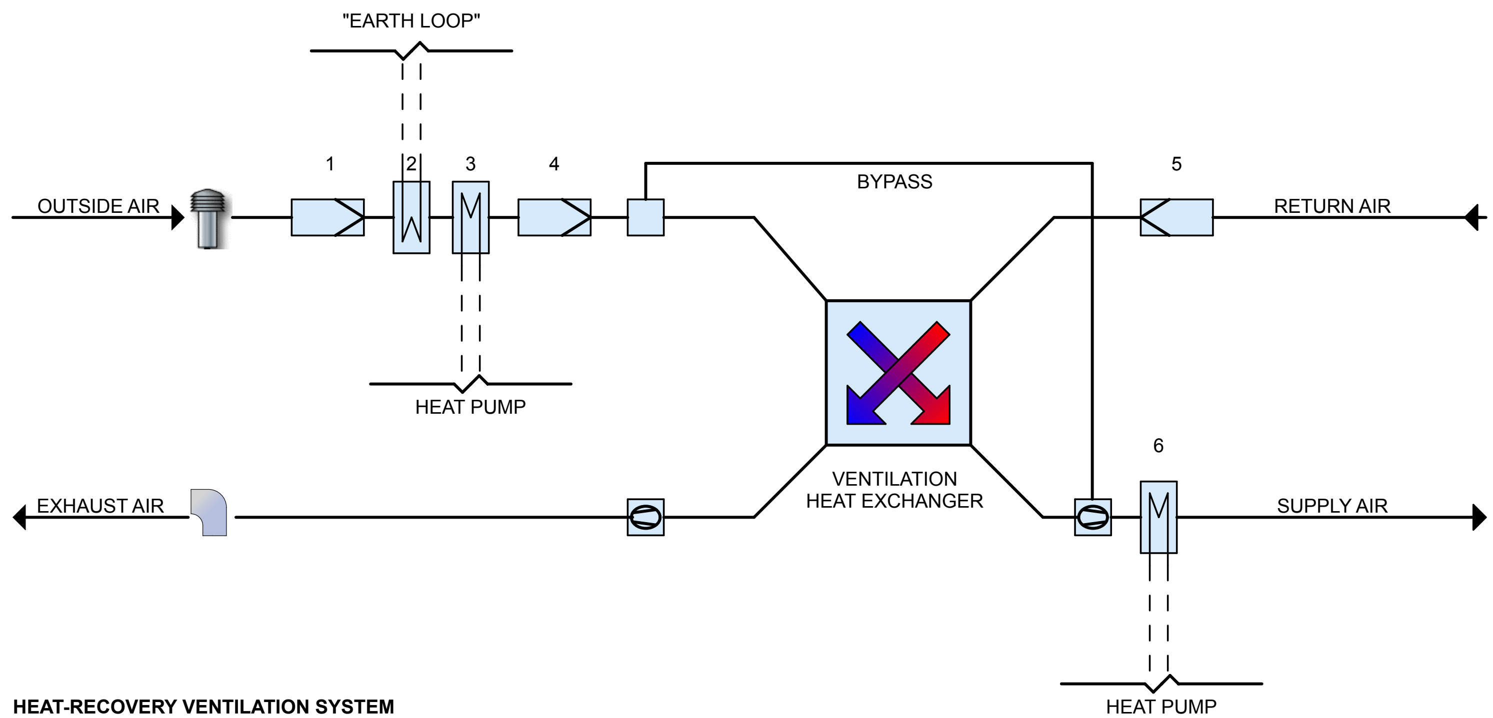
| | |
|---|---|
| 设计 | |
| 校对 | |
| 审核 | |
| 专业负责 | |
| 比例 | 1:5 |
| 图号 | JD-15 |
| 图幅 | A2 |
| 专业 | 幕墙 |
| 版号 | A |
| 阶段 | 施工图 |
| 工程编号 | |

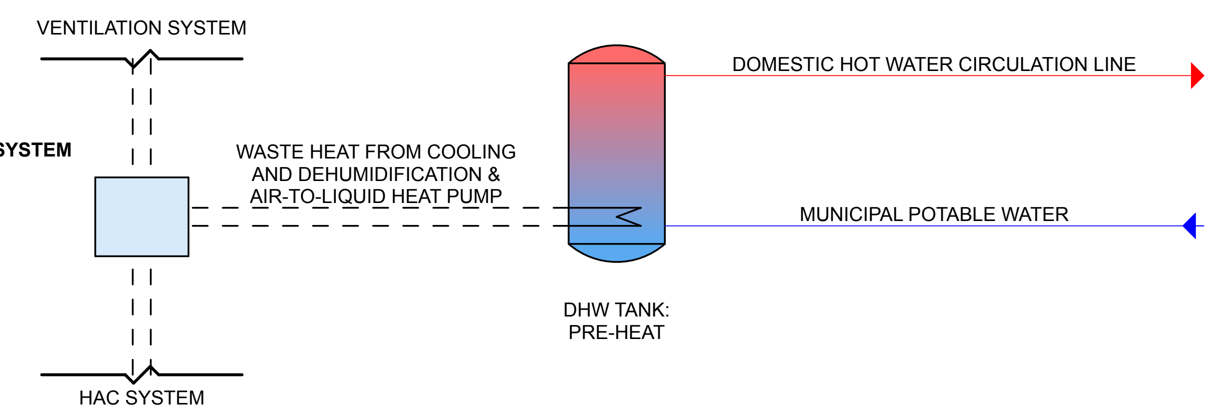
出图签章:

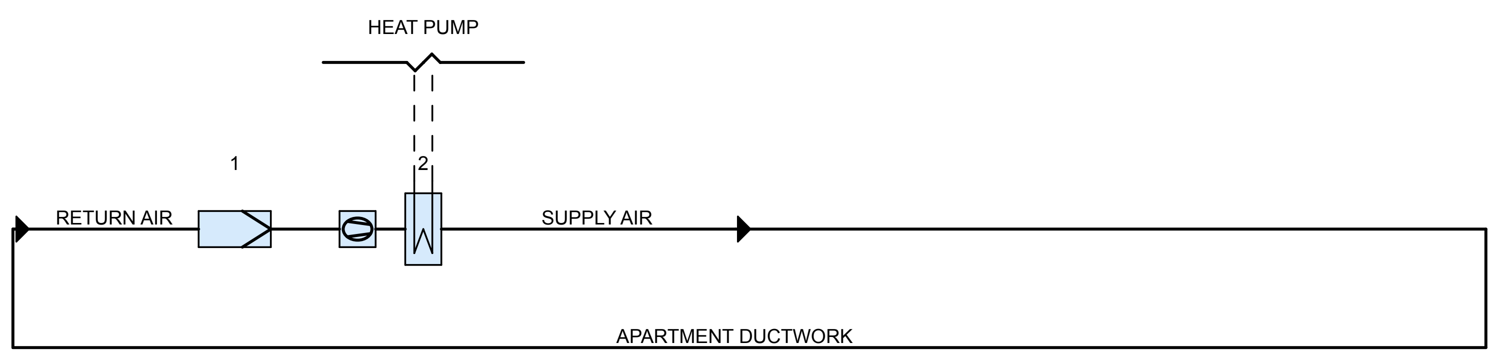
# MEP Strategies




**HEAT-RECOVERY VENTILATION SYSTEM**
1 PRE-FILTER
2 LIQUID-TO-AIR HEAT EXCHANGER: FROST-PROTECTION, PRE-COOL, DEHUMIDIFICATION
3 LIQUID-TO-AIR HEAT EXCHANGER: PRE-COOL, DEHUMIDIFICATION
4 OUTSIDE AIR FILTER
5 RETURN AIR FILTER
6 LIQUID-TO-AIR HEAT EXCHANGER: POST-HEAT

**AIR-TO-LIQUID HEAT PUMP SYSTEM**
AIR-TO-LIQUID HEAT PUMP:
- LOAD SHIFTING
- HEATING
- COOLING
- DEHUMIDIFICATION




**HEATING, COOLING & DEHUMIDIFICATION (HAC) SYSTEM**
1 RETURN AIR FILTER
2 LIQUID-TO-AIR HEAT EXCHANGER

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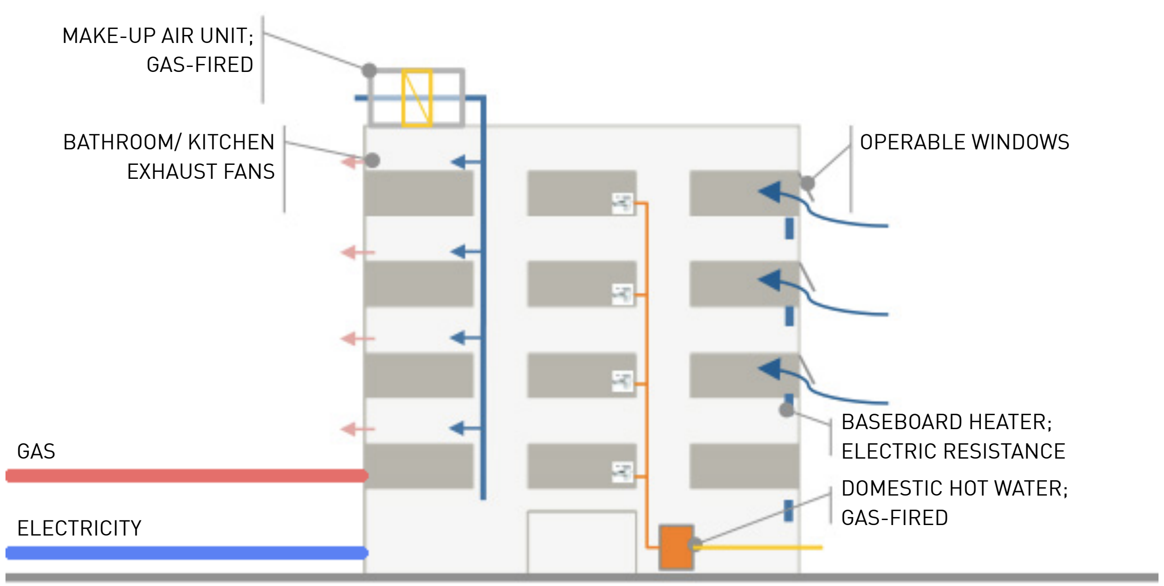
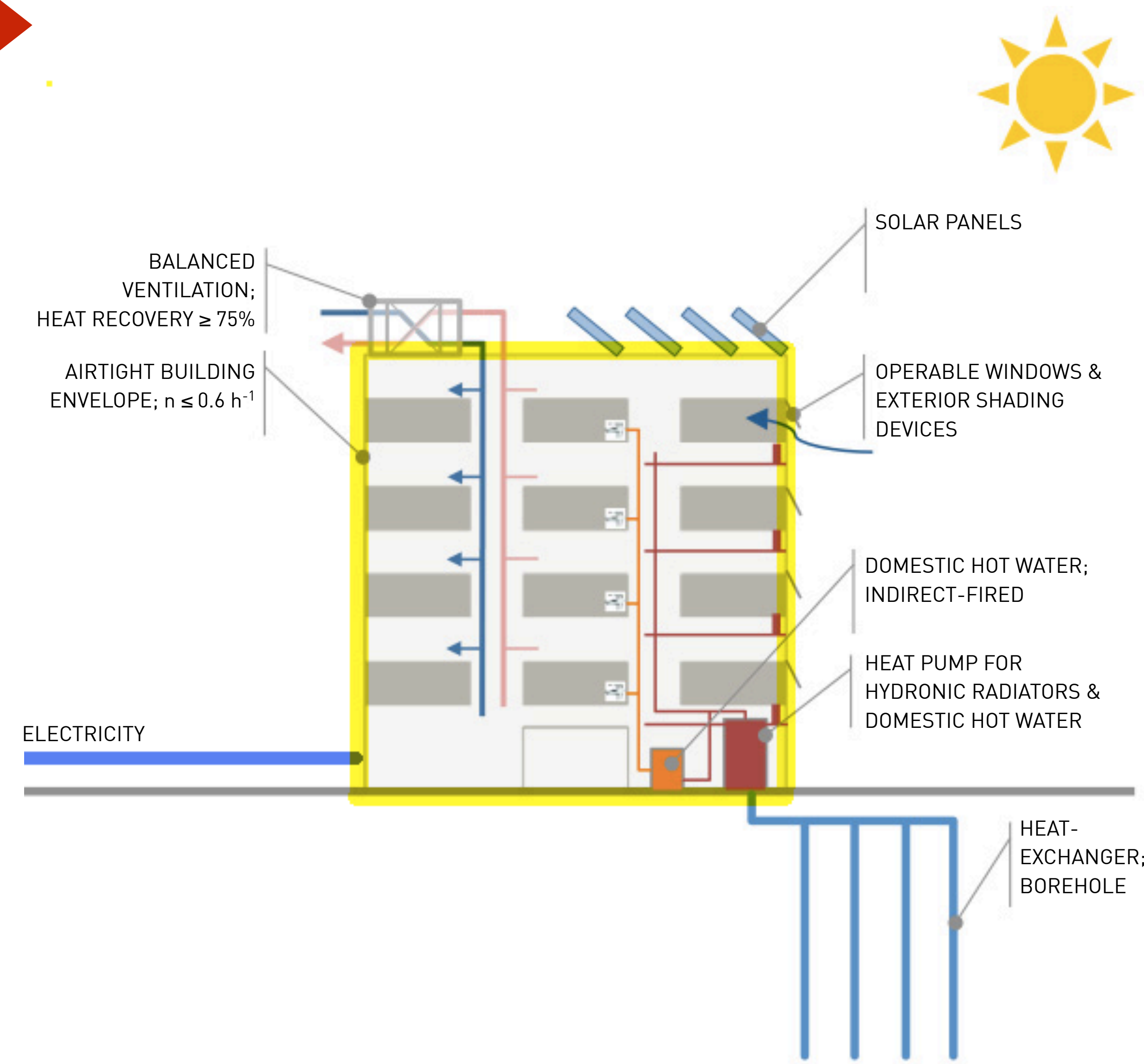
# System Opportunties




CURRENT TECHNOLOGY




EXAMPLE: 2020 TECHNOLOGY

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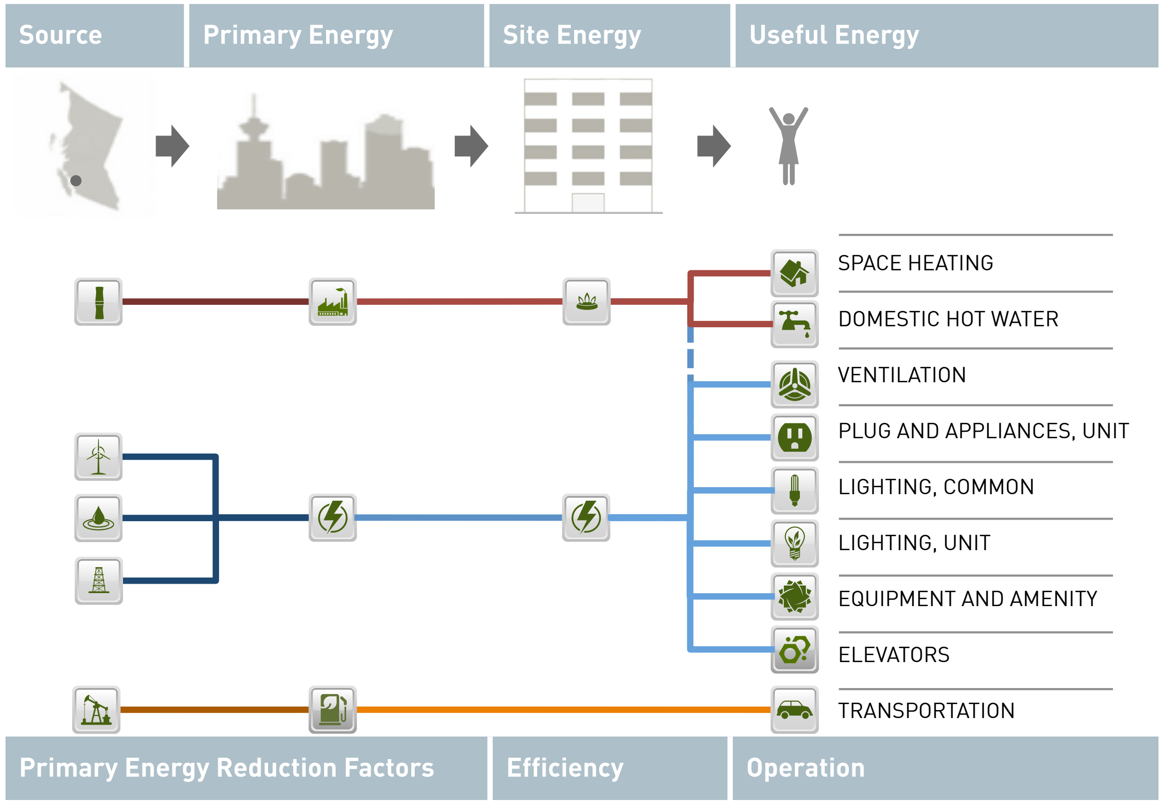
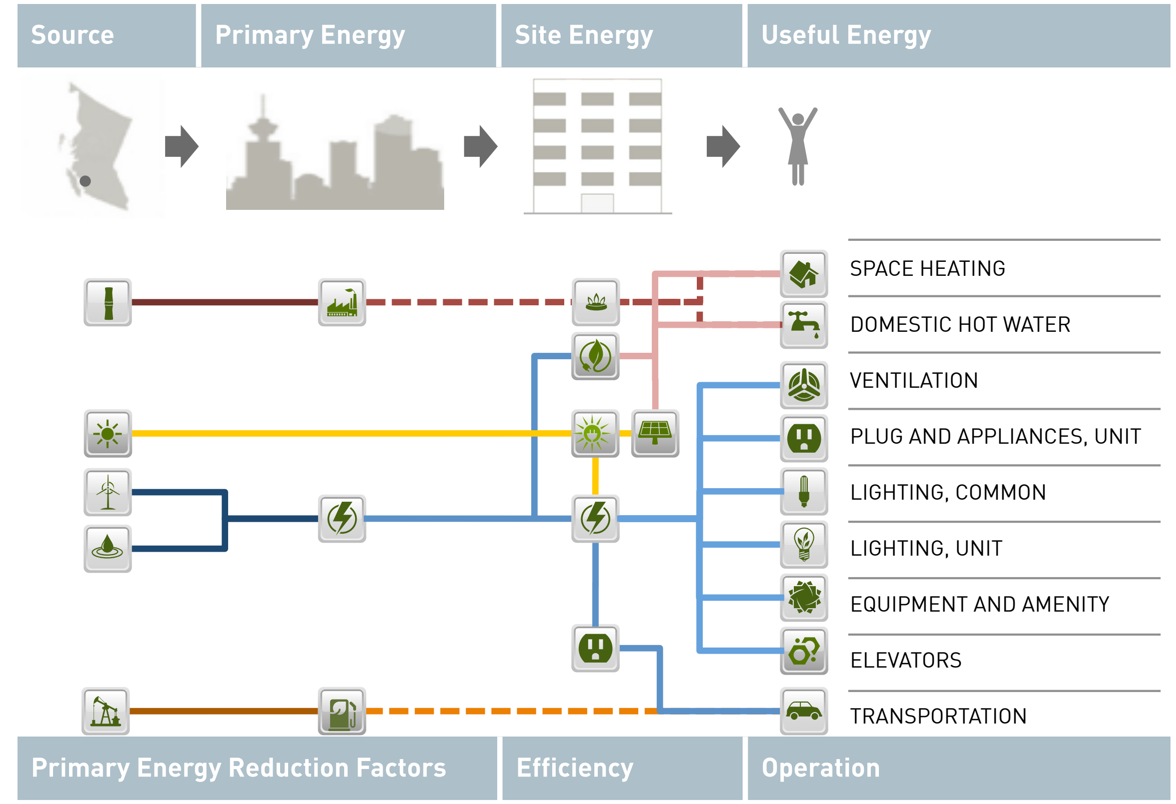
# Resource Shifting




Energy avoidance enables:

- Use of renewable resources, energy independence
- Resilience (extended periods of coasting)
- Offset with decentralized systems

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# Key Conclusions & Benefits

- Goal setting right in the beginning is key
- Team selection is crucial
- Understanding high-performance building envelope principles is critical
- First design and model, then build
- Understanding the life-cycle cost impact versus first day cost is key to fiscal success, and true value engineering

# Case Study 4

## Hook & Ladder Apartments - Affordable Housing

Minneapolis, MN - 2016/18


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# Project

**59-unit, affordable multi-family housing project. 61,000 gross sf. on 5-stories. First certified multi-family Passive House in Minnesota.**

- Differences in Construction
- Differences in Systems
- First Day Cost Comparison
- Life Cycle Cost Comparison
- Site and Source Energy Comparison
- Carbon Comparison
- Conclusion and Benefits

# Differences in Construction

| **Building Envelope** | **Base** | **Passive House** |
|---|---|---|
| Exterior Walls | R-22 (h sf °F)/Btu | R-45 (h sf °F)/Btu |
| Roof | R-40 (h sf °F)/Btu | R-65 (h sf °F)/Btu |
| Slab | R-10 (h sf °F)/Btu | R-25 (h sf °F)/Btu |
| Windows | U-Factor: 0.30 Btu/(h sf °F)<br>SHGC: 30% | U-Factor: 0.14 Btu/(h sf °F)<br>SHGC: 26% |
| Thermal Bridges | No consideration | Thermal bridge free design |
| Airtightness | No consideration | $ACH_{50}$: 0.2 $^{1}/_{h}$<br>(Preset and field-measured) |

# Differences in Systems

| System | Base | Passive House |
|---|---|---|
| **Ventilation** | Assumed bypass inside "magic pack" heating and cooling system in combination with individual bathroom exhaust fans. | Balanced whole-house heat recovery ventilation system with Passive House recovery efficiency: 87%<br>Electric efficiency: 0.45 $Wh/m^3$<br>Automated controls based on air quality |
| **Heating/ Cooling** | Individual apartment "magic pack" units with ducted distribution (gas furnace heat, electric air-conditioning) | Single, whole-house air-source electric heat-pump with individual apartment indoor units and ducted distribution (electric heating and air-conditioning) |
| **Domestic Hot Water** | Central gas-fired domestic hot water boilers with circulation line | Summer: heat recovery from air-conditioning to domestic hot water system; summer and winter: gas-fired backup boiler with circulation line |

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# First Day Cost Comparison

Based on predesign analysis, the first day investment cost for the Passive House building is between 7.5 and 17% above the cost for the base building (MN code).

This is the first project of its kind in the region and the developer and build teams are new to Passive House making this a pilot project.

# Life Cycle Cost Comparison

| | 60 years | 50 years | 40 years | 30 years | 20 years | 10 years |
|---|---|---|---|---|---|---|
| Passive House (high) savings | 6.36% | 7.03% | 3.95% | **3.13% cheaper** | 1.31% | -5.40% |
| Passive House (low) savings | 11.95% | 12.87% | 9.00% | **8.63% cheaper** | 6.05% | -0.08% |

# Site Energy Comparison

| | Heating Energy (kBTU/ yr) | Total Energy (kWh/ yr) | Total Energy (kBTU/ yr) | Energy Use Index (kWh/ gsf) | Energy Use Index (kBTU/ gsf) |
|---|---|---|---|---|---|
| US existing | | | | | 78.8 |
| Base | 116,360 | 581,254 | 1,983,795 | 9.5 | 32.6 |
| Passive House | 3,792 | 196,024 | 669,021 | 3.2 | 6.6 |
| Passive House Savings | 112,568 (97% less) | 385,230 less | 1,314,774 less | 66% less | 66% less (92% less than existing) |

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# Energy Cost Comparison

| | **Cost Index ($/ gsf)** |
|---|---|
| Base | 0.482 |
| Passive House | 0.328 |
| Passive House Savings | 32% less |

# Source Energy Comparison

| | Total source energy (kWh/ yr) | Source Energy Use Index (kWh/ gsf) | Source Energy Use Index (kBTU/ gsf) |
|---|---|---|---|
| US existing | | | 127.9 |
| Base | 1,106,432 | 18.2 | 62.0 |
| Passive House | 401,686 | 6.6 | 22.5 |
| Passive House Savings | 704,746 less | 64% less | 64% less (82% less than existing) |

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# Carbon Comparison

| | Total $CO_2$ Impact (tons $CO_2$ equ.) | $CO_2$ Impact Index (kg $CO_2$ equ./ gsf) |
|---|---|---|
| Base | 184 | 3.03 |
| Passive House | 109 | 1.79 |
| Passive House Savings | 75 less | 41% less |

# Key Conclusions & Benefits

- Differences in construction and systems are manageable but require diligent, experienced design team—particularly for energy modeling and detail design
- Passive House costs “differently” on day 1
- Life Cycle cost are cheaper (not putting any cost value on human benefits of Passive House design)
- Energy performance is entirely different; heating is no longer a major consumer of energy; domestic hot water production and plug loads need to be managed and reduced
- Fits the paradigm of a sustainable building

# Discussion

# Thank You.

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