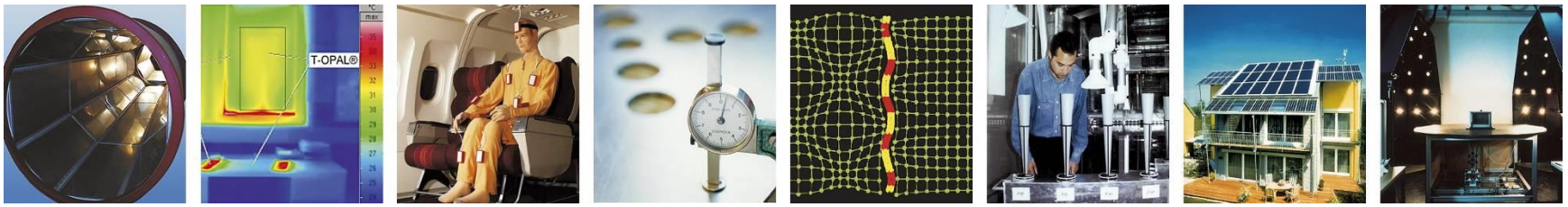
Moisture risks of passive retrofitting one town house for the adjacent conventional neighboring structures

9th Passive house conference, September 10-14, 2014, San Francisco

Matthias Pazold

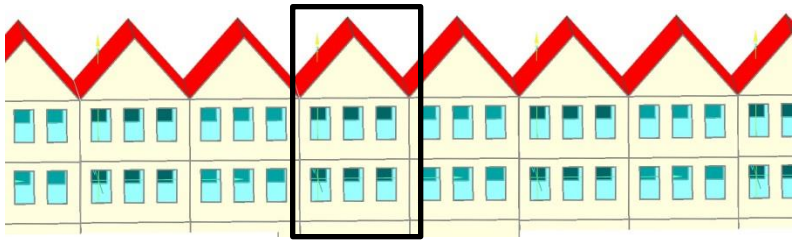
Auf Wissen bauen



Fraunhofer IBP

Issue

- A town house / row house is retrofitted by interior insulation
- Will moisture risks occur in the party wall?
  - depending on construction type
  - depending on climate



Agenda

- Methodology
- Investigated Building model
- Some Results

simulation methodology

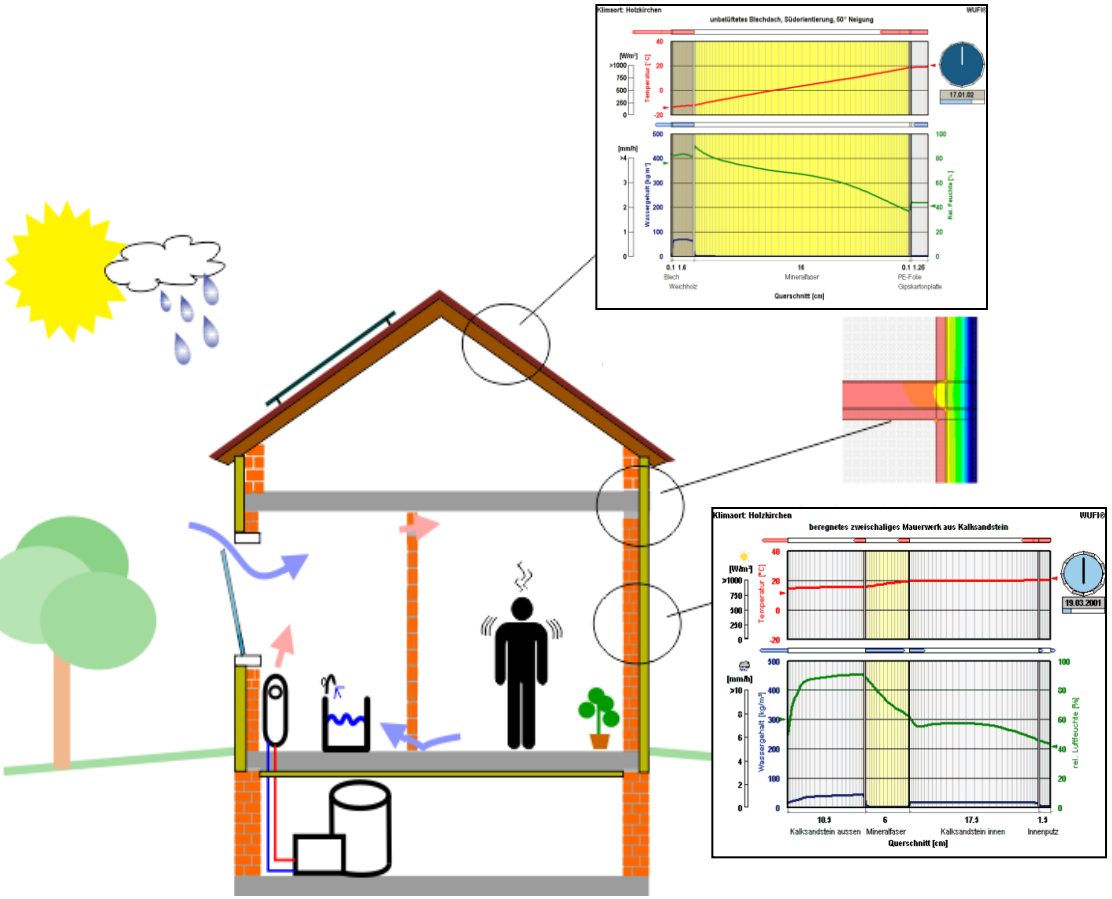
Steady state method vs. dynamic simulation

- Steady state methods, don't tell much about the moisture risks

- Used software: WUFI® Passive – **the dynamic side**
  - simulate the hygrothermal behavior of the building envelope
  - simulate the indoor climate
  - and simulate the 2D or 3D thermal behavior of thermal bridges

simulation methodology

WUFI® Passive – the dynamic side

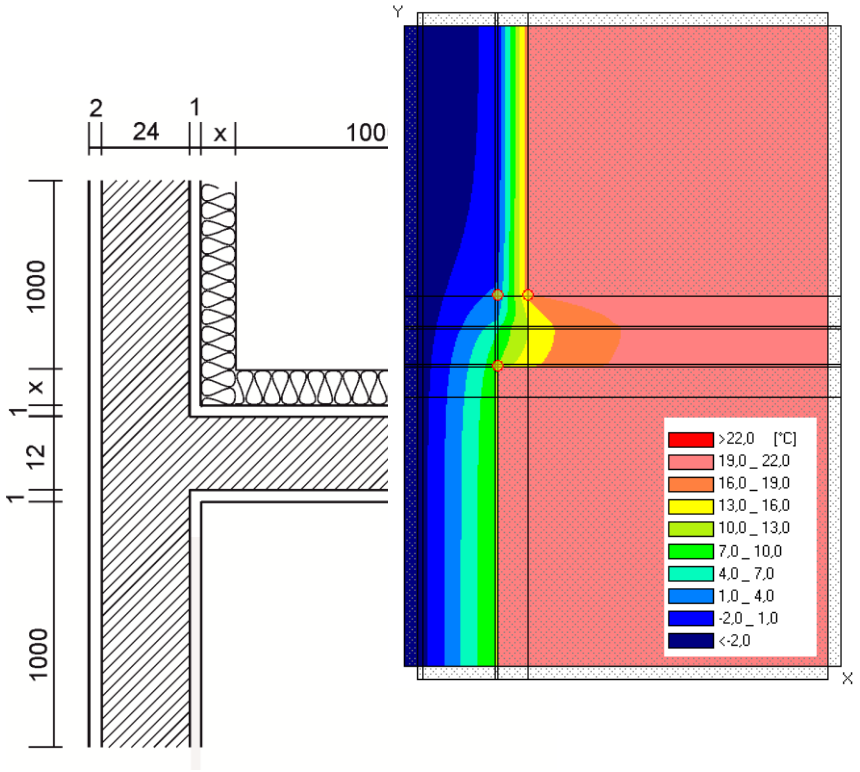


Fraunhofer IBP

simulation methodology

WUFI® Passive – the dynamic side

- Dynamic thermal simulation of thermal bridges
- calculates the temperature field within 2D or 3D Objects
- heat exchange with simulated zones
- heat exchange with the outer climate

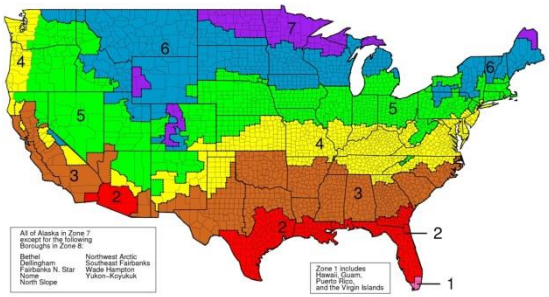


Fraunhofer IBP

simulation methodology

Case study - overview

- different climate zones
  - San Francisco (3C warm - marine)
  - Chicago (5A cold - humid)



- different construction types:
  - brick
  - wood frame

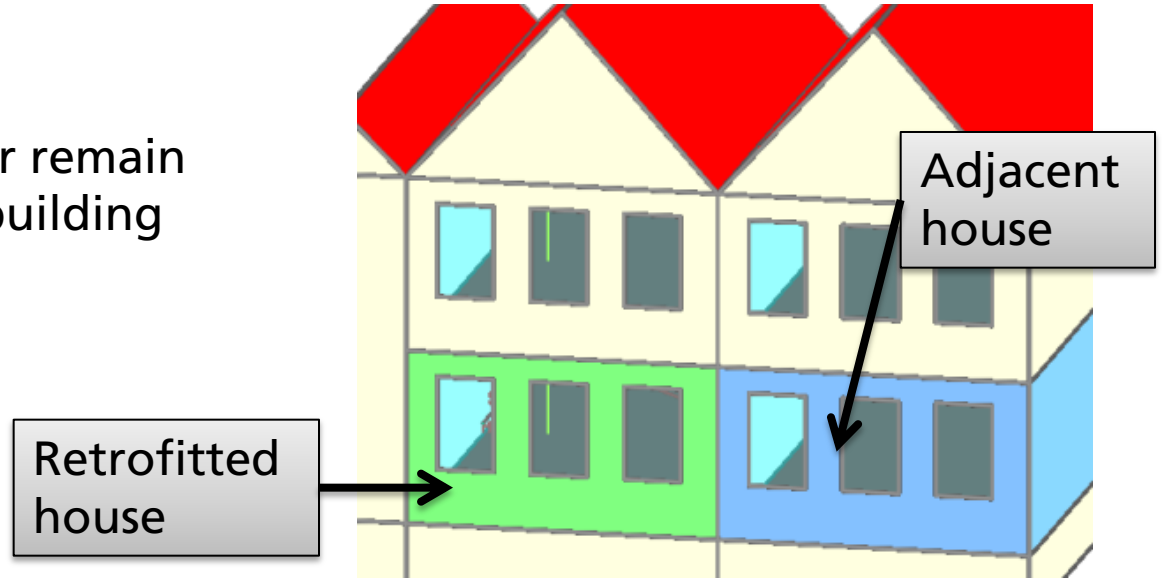
Fraunhofer IBP

Investigated building model

Investigated building model

Instead of the whole building, just two adjacent Townhouse floors

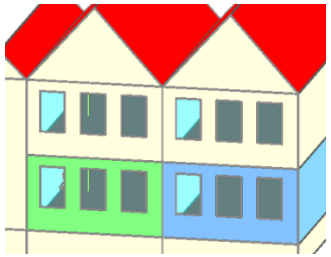
- The green colored floor is within the retrofitted house
- The blue colored floor remain with a conventional building structure



Investigated building model

Dimensions / Geometry

Retrofitted house



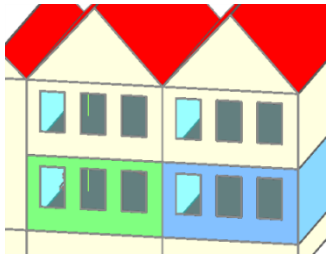
Adjacent house

- Treated floor area: 480 ft²
- Clearance height: 8.2 ft
- Net volume: 3900 ft³

Investigated building model

Internal loads / Occupancy

Retrofitted house



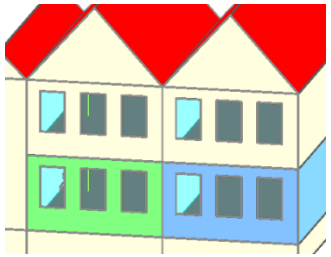
Adjacent house

- Internal heat gain: 0.7 Btu/hr ft²
- Moisture sources: 0.0004 lb / ft² hr

Investigated building model

Ventilation

Retrofitted house



Adjacent house

- Infiltration
  ACH 0.05 (ACH50 0.6)
- Natural ventilation
  ACH 0.05
- + mechanical ventilation
  ACH 0.3

- Infiltration
  ACH 0.35 (ACH50 5)
- Natural ventilation
  ACH 0.05
- No mechanical ventilation

Brick construction – San Francisco (3C)

Brick construction – San Francisco

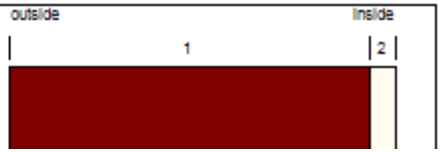
Building Assemblies / Material

adjacent and retrofitted **brick** construction: **Exterior wall**

Homogenous layers

Thermal resistance: 3,345 hr ft² °F/Btu

Heat transfer coefficient(U-value): 0,23 Btu/hr ft² °F



Thickness: 8,685 in

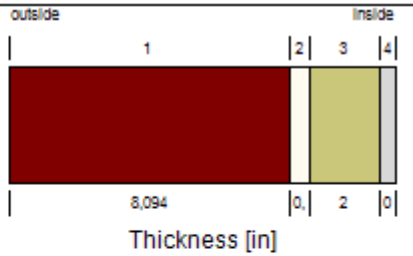
Nr.	Mater (from outs
1	Brick (old)
2	Interior Plaster (Gypsum Pl

+ interior insulation

Homogenous layers

Thermal resistance: 15,326 hr ft² °F/Btu

Heat transfer coefficient(U-value): 0,06 Btu/hr ft² °F



Thickness: 11,177 in

Nr.	Material/Layer (from outside to inside)	ρ [lb/ft³]	c [Btu/lb°F]	λ [Btu/hr ft °F]	Thickness [in]	Color
1	Brick (old)	104,25	0,2	0,2311	8,094	
2	Interior Plaster (Gypsum Plaster)	53,06	0,2	0,1156	0,591	
3	Sprayed Polyurethane Foam; closed cell	2,43	0,35	0,0144	2	
4	Interior Gypsum Board	39,02	0,21	0,0924	0,492	

Fraunhofer IBP

Brick construction – San Francisco

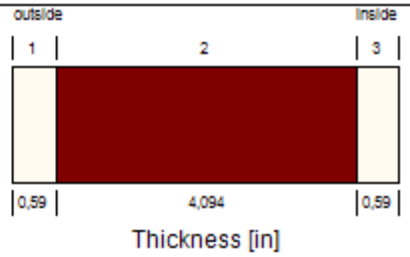
Building Assemblies / Material

adjacent and retrofitted **brick** construction: **Party wall**

Homogenous layers

Thermal resistance: 2,329 hr ft² °F/Btu

Heat transfer coefficient(U-value): 0,26 Btu/hr ft² °F



Thickness: 5,276 in

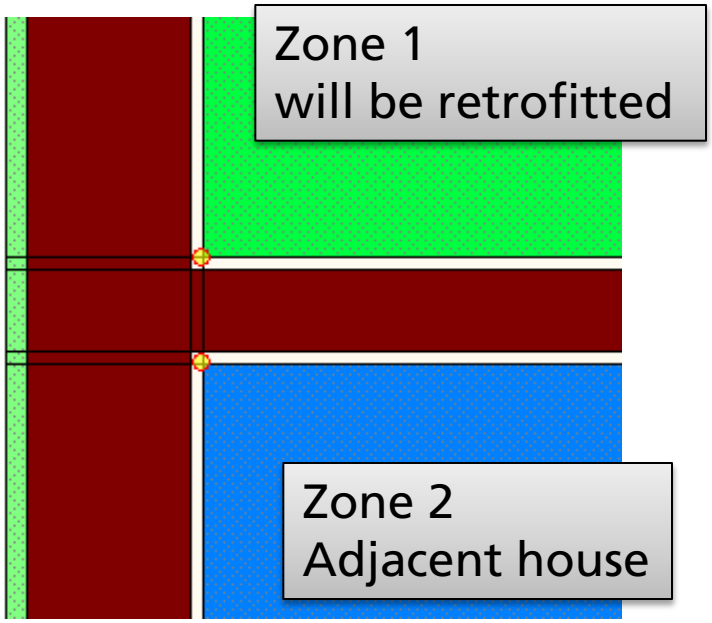
Nr.	Material/Layer (from outside to inside)	ρ [lb/ft³]	c [Btu/lb°F]	λ [Btu/hr ft °F]	Thickness [in]	Color
1	Interior Plaster (Gypsum Plaster)	53,06	0,2	0,1156	0,591	
2	Brick (old)	104,25	0,2	0,2311	4,094	
3	Interior Plaster (Gypsum Plaster)	53,06	0,2	0,1156	0,591	

Not refurbished

Brick construction – San Francisco

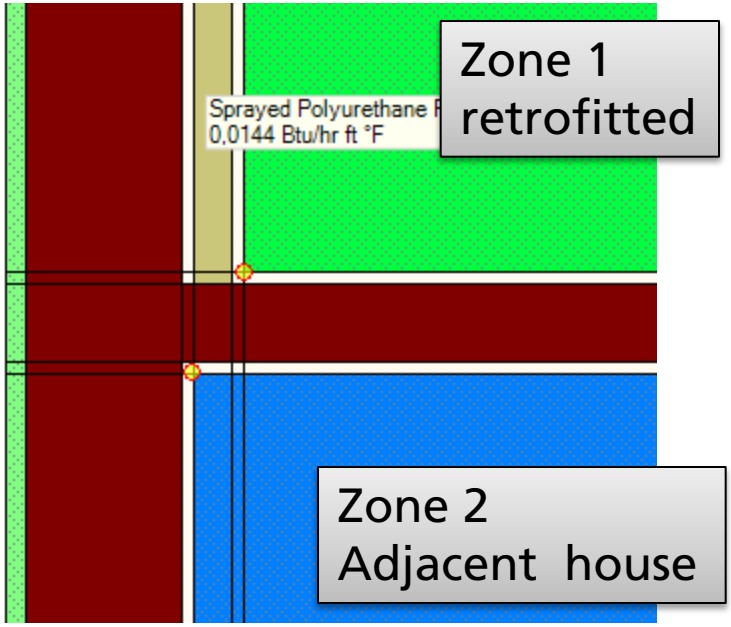
Cross section of the junction of **exterior** and **party wall**

Prior retrofit



Past retrofit

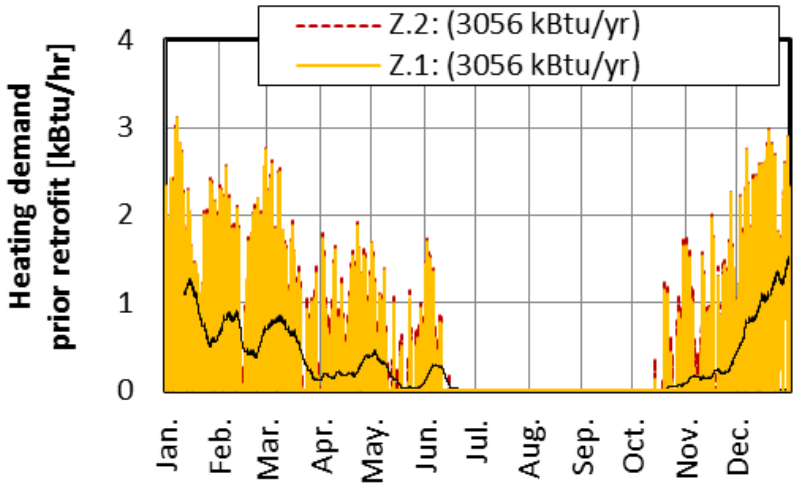
2 in (interior insulation)



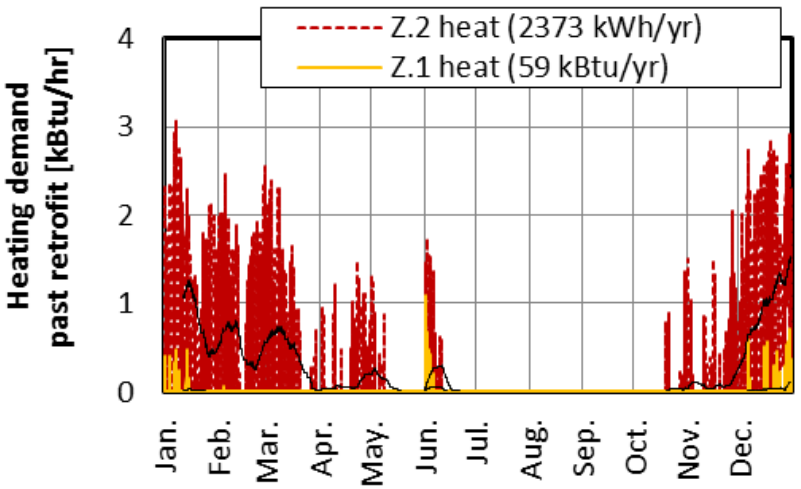
Brick construction – San Francisco

Simulation results – Heating demand

Prior retrofit



Past retrofit



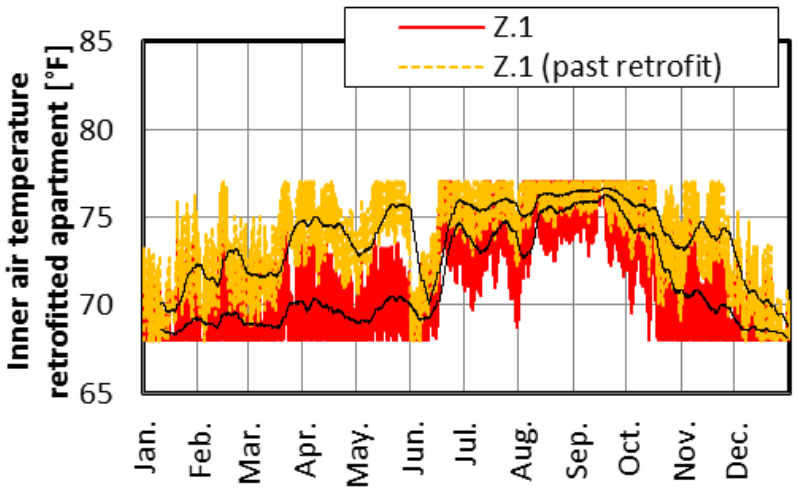
- Decrease of the heating demand
  - Retrofitted floor 5.7 to 0.1 kBtu/ft² yr (≈98%)
  - Adjacent floor 5.7 to 4.4 kBtu/ft² yr (≈22%)

Fraunhofer IBP

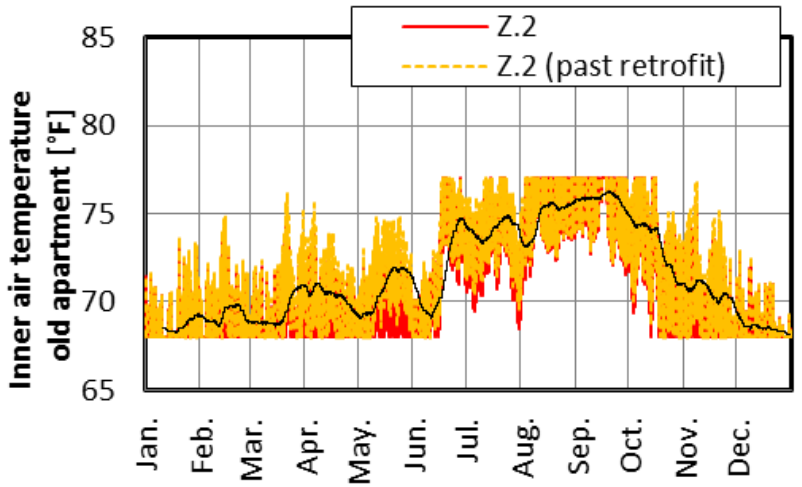
Brick construction – San Francisco

Results – Inner air temperature

Retrofitted house



Adjacent house

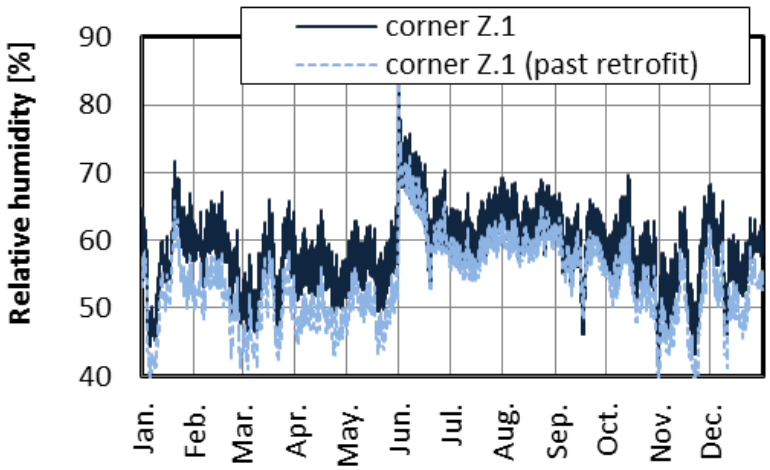


Fraunhofer IBP

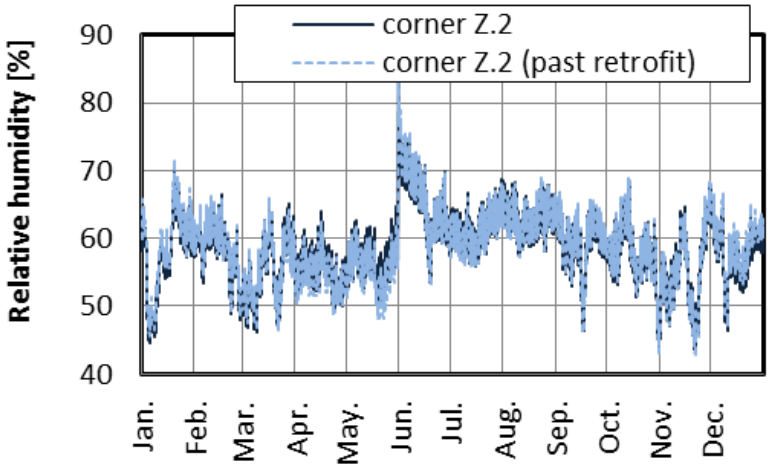
Brick construction – San Francisco

Results – moisture risk on the junction exterior - party wall

Retrofitted house



Adjacent house



- no increased moisture risk in the
  in the critical exterior wall – party wall corner

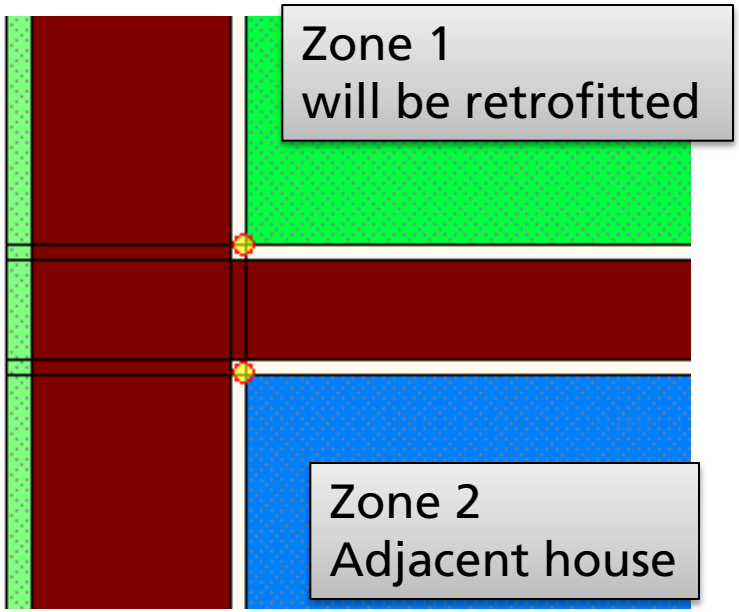
Fraunhofer IBP

Brick construction – Chicago (5A)

Brick construction – Chicago

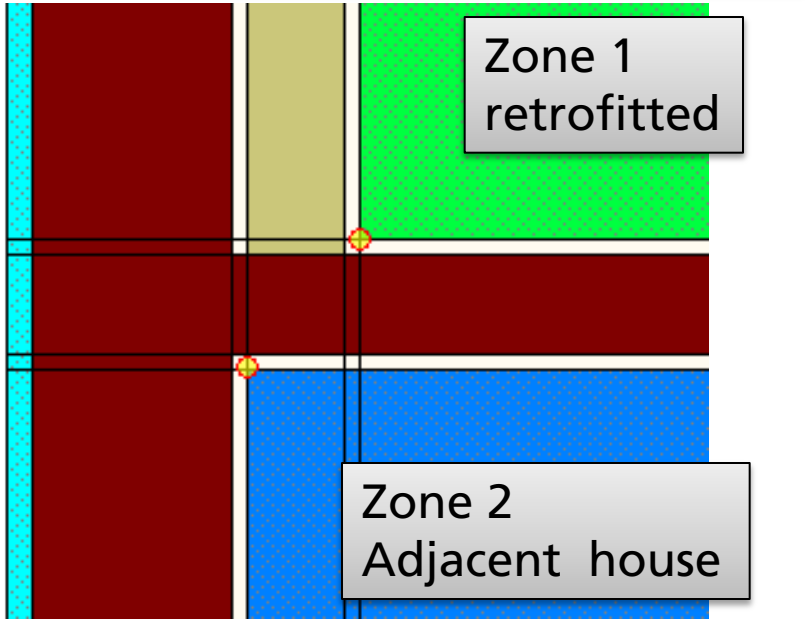
Cross section of the junction of **exterior** and **party wall**

Prior retrofit



Past retrofit

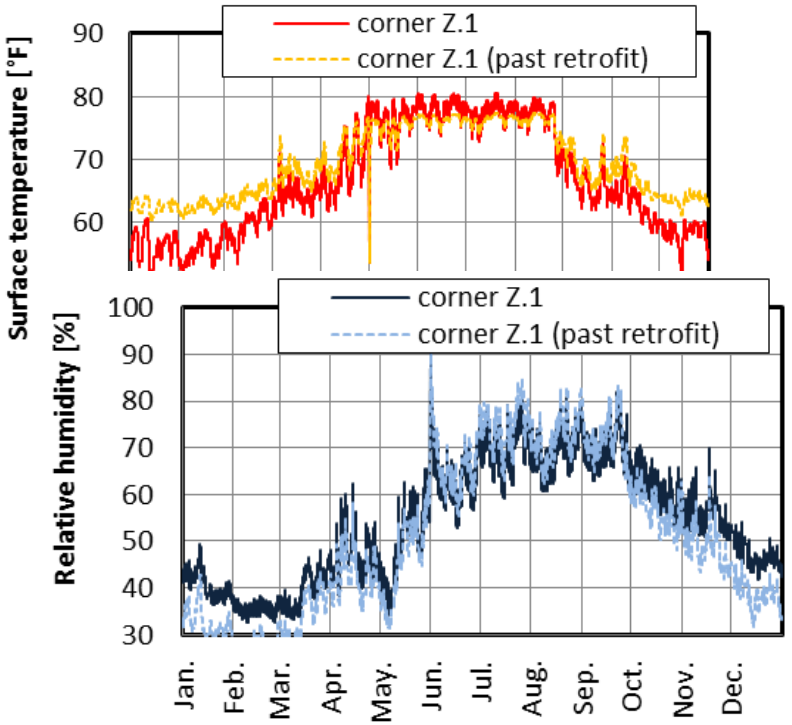
4 inch (interior insulation)



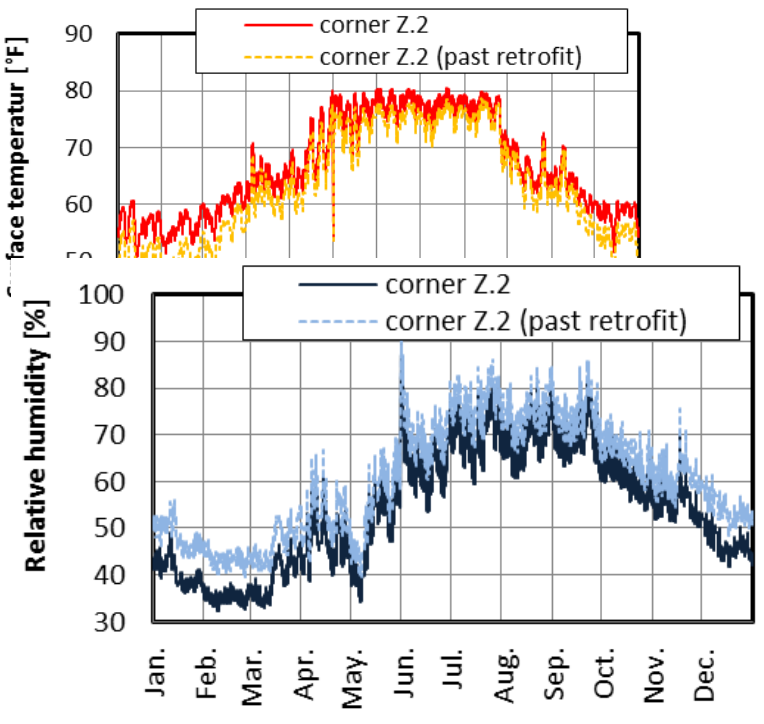
Brick construction – Chicago

Results – moisture risk on the junction exterior - party wall

Retrofitted house



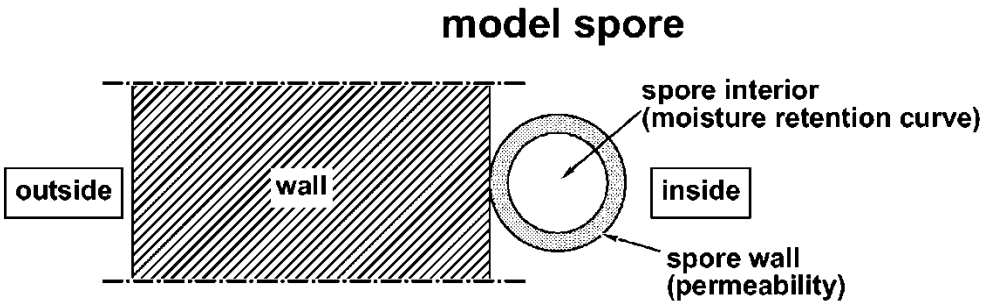
Adjacent house

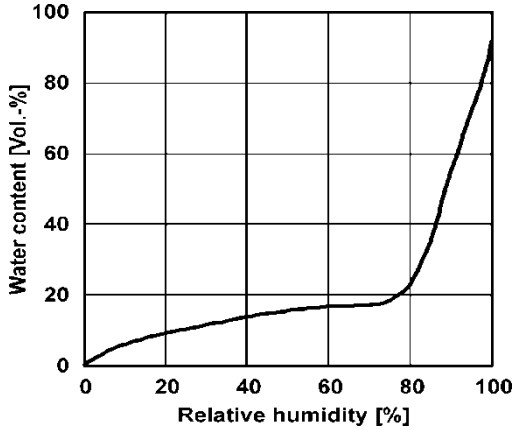


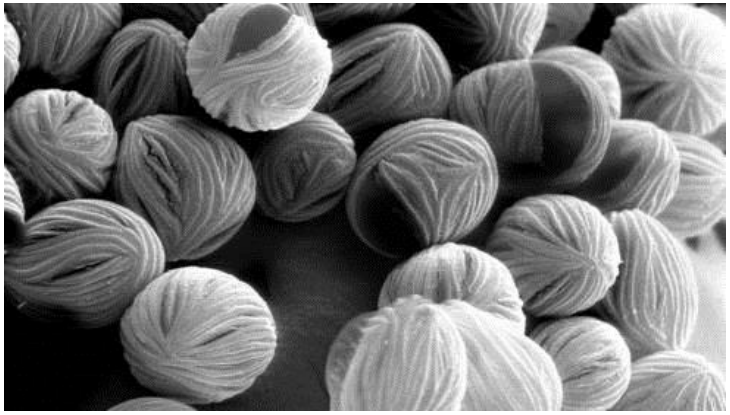
Fraunhofer IBP

Brick construction – Chicago

Results –assessment of the mould growth risk with WUFI® Bio





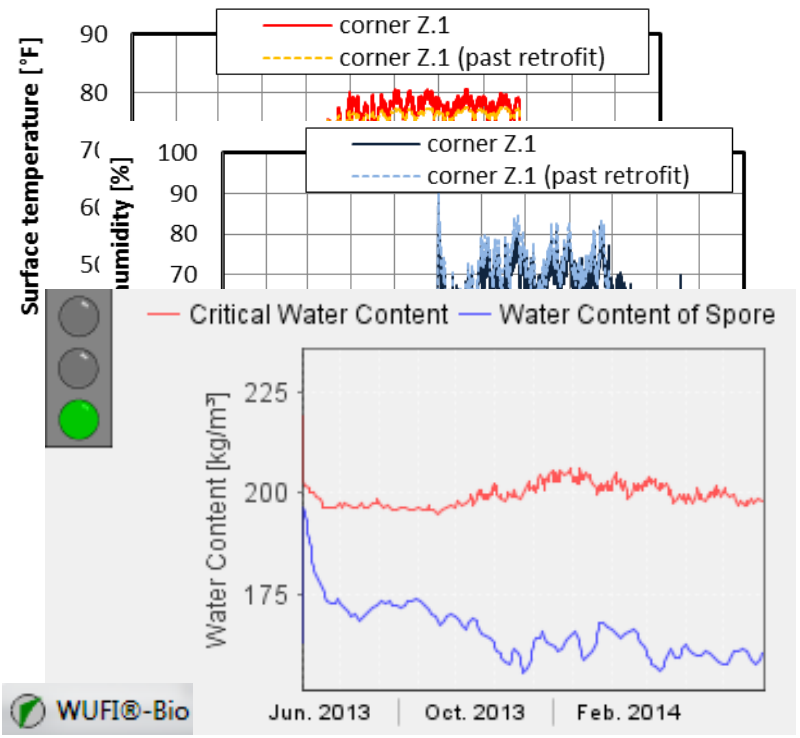


Fraunhofer IBP

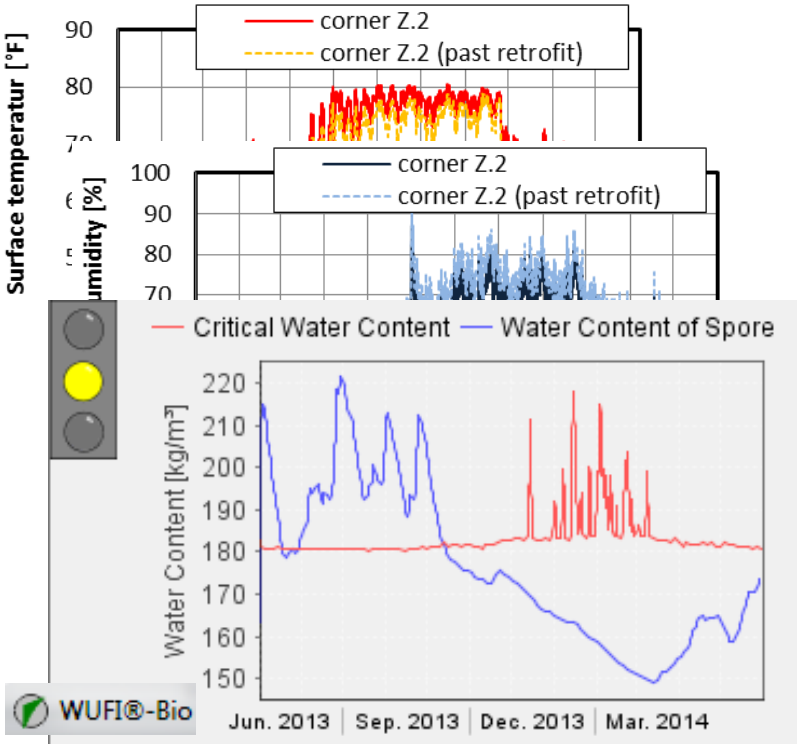
Brick construction – Chicago

Results – moisture risk on the junction exterior - party wall

Retrofitted house



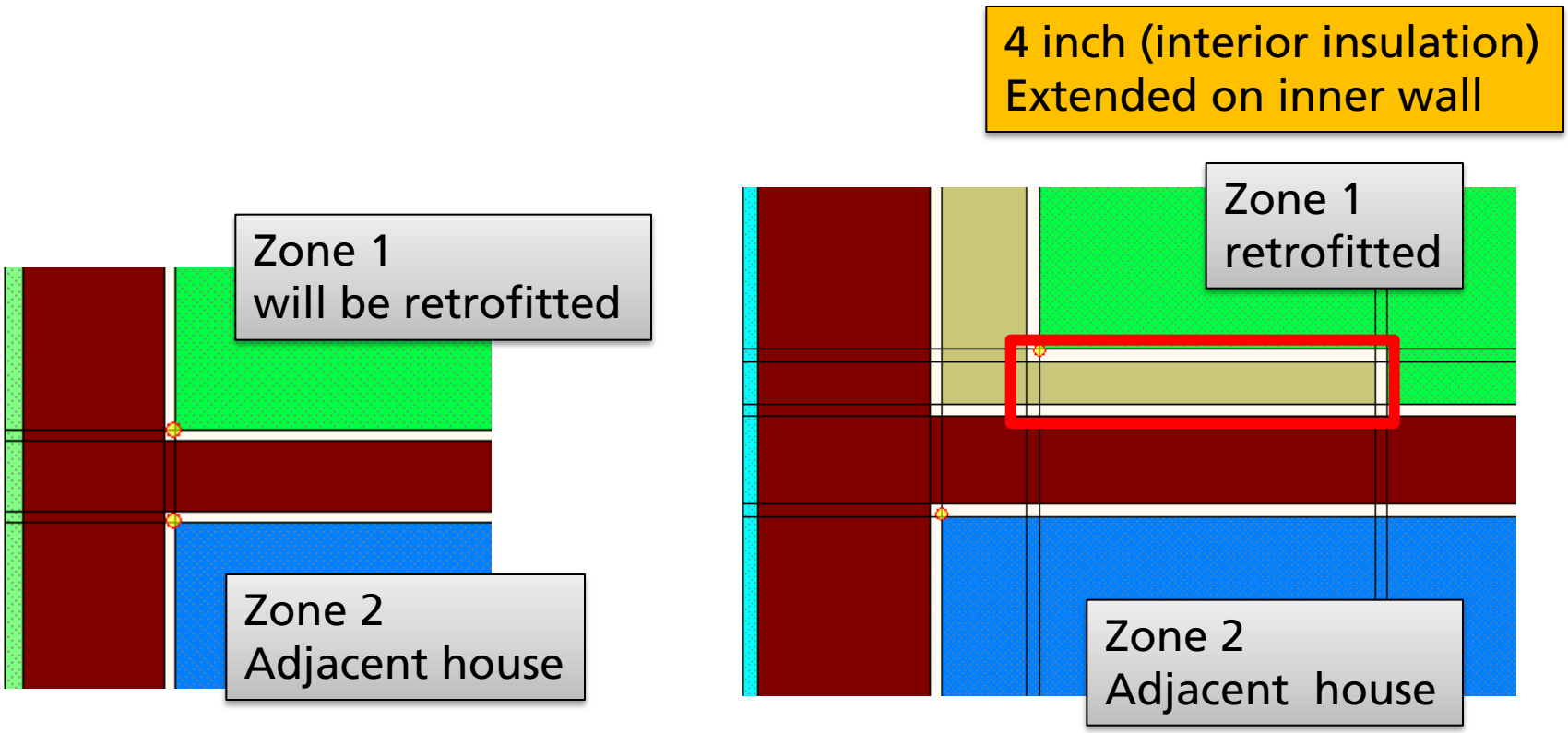
Adjacent house



Fraunhofer IBP

Brick construction – Chicago

Cross section of the junction of **exterior** and **party wall**

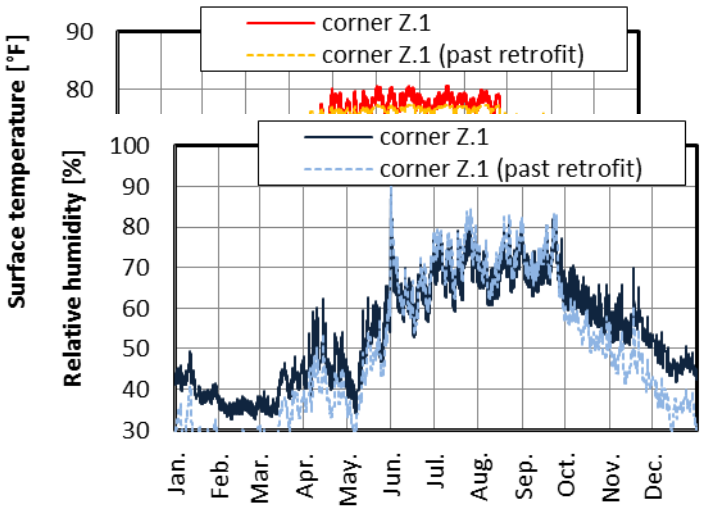


Fraunhofer IBP

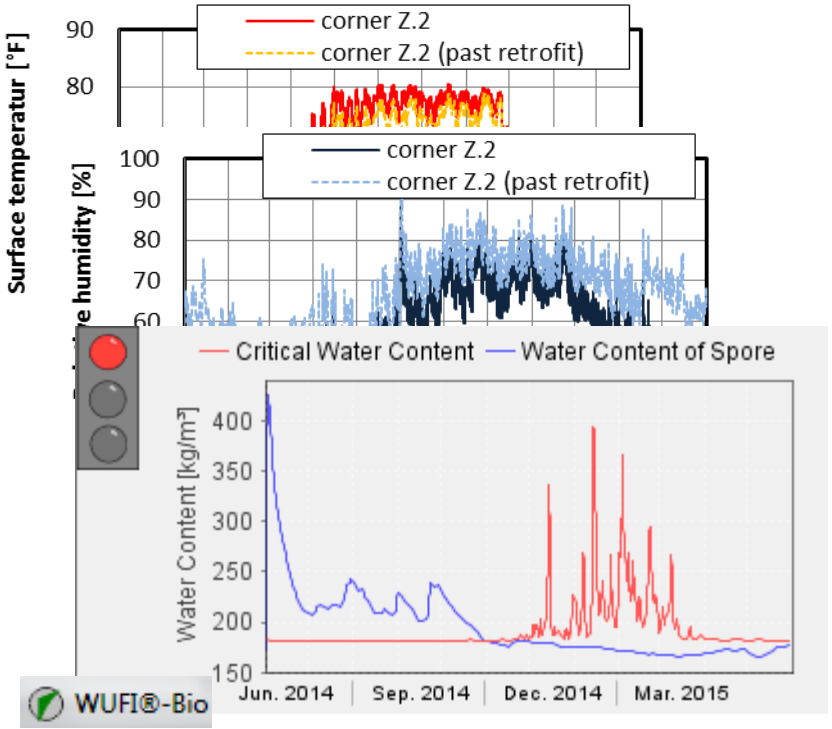
Brick construction – Chicago

Results – moisture risk on the junction exterior - party wall

Retrofitted house



Adjacent house



Fraunhofer IBP

Wood frame construction – San Francisco (3C)

Wood frame construction – San Francisco

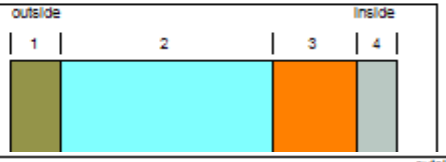
Building Assemblies / Material

neighboring and retrofitted **wood frame** construction: **exterior wall**

Homogenous layers

Thermal resistance: 5,227 hr ft² °F/Btu

Heat transfer coefficient(U-value): 0,16 Btu/hr ft² °F



Thickness: 4,567 in

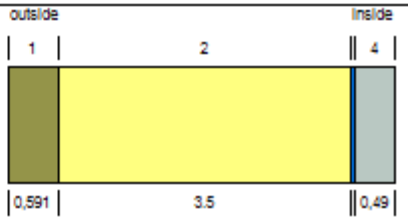
Nr.	Material/L (from outside t
1	Plywood (USA)
2	Air Layer 30 mm
3	Wood-Wool Board
4	Gypsum Board (USA)

+ new insulation between studs

Homogenous layers

Thermal resistance: 15,875 hr ft² °F/Btu

Heat transfer coefficient(U-value): 0,06 Btu/hr ft² °F



Thickness: 4,622 in

Nr.	Material/Layer (from outside to inside)	ρ [lb/ft³]	c [Btu/lb°F]	λ [Btu/hr ft °F]	Thickness [in]	Color
1	Plywood (USA)	29,34	0,45	0,0485	0,591	
2	Fibre Glass	1,87	0,2	0,0202	3,5	
3	vapor retarder (5perm)	8,12	0,55	1,3289	0,039	
4	Gypsum Board (USA)	53,06	0,21	0,0942	0,492	

Fraunhofer IBP

Wood frame construction – San Francisco

Building Assemblies / Material

neighboring and retrofitted **brick** construction: **Party wall**

Homogenous layers

Thermal resistance: 12,186 hr ft² °F/Btu

Heat transfer coefficient(U-value): 0,07 Btu/hr ft² °F

Thickness: 9,661 in

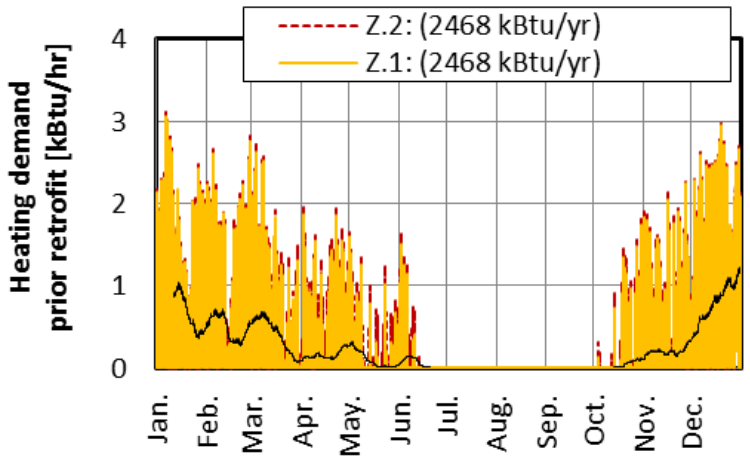
Nr.	Material/Layer (from outside to inside)	ρ [lb/ft³]	c [Btu/lb°F]	λ [Btu/hr ft °F]	Thickness [in]	Color
1	Gypsum Board (USA)	53,06	0,21	0,0942	0,492	
2	Air Layer 25 mm	0,08	0,24	0,0896	2,5	
3	Wood-Wool Board	28,09	0,36	0,0462	0,952	
4	Plywood (USA)	29,34	0,45	0,0485	0,591	
5	Air Layer 10 mm	0,08	0,24	0,041	0,591	

Not refurbished

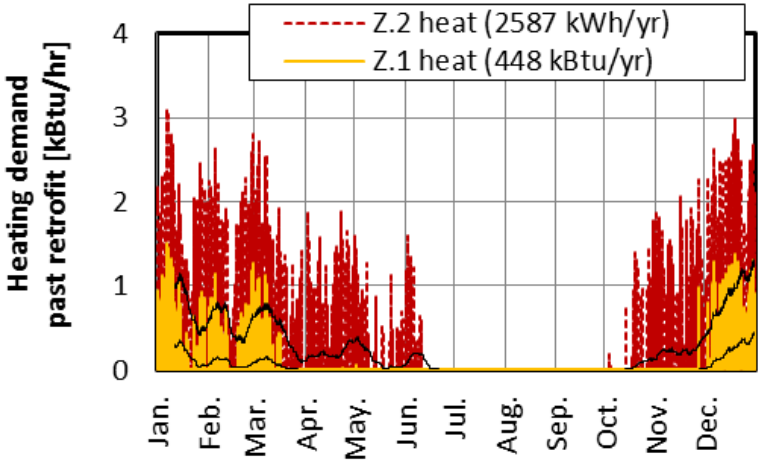
Wood frame construction – San Francisco

Simulation results – Heating demand

Prior retrofit



Past retrofit



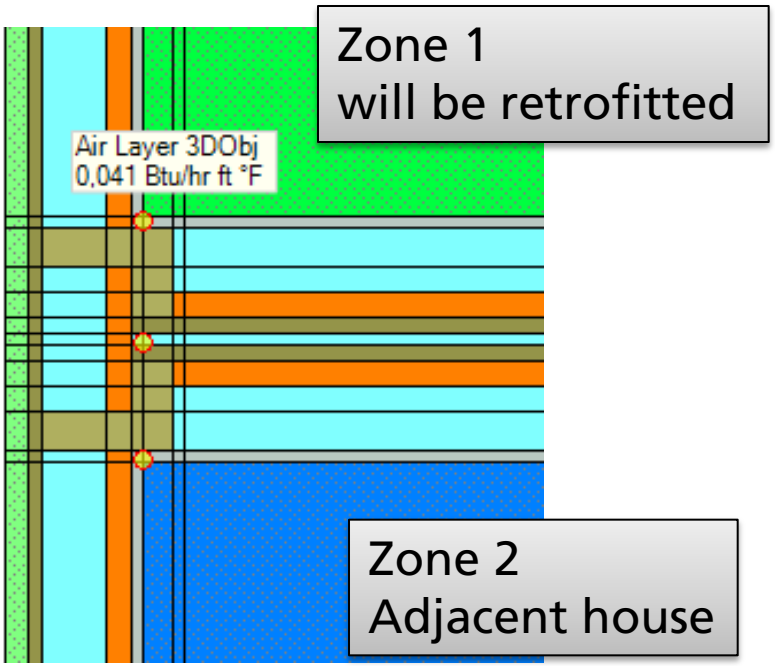
- Decrease of the heating demand
  - Retrofitted floor 4.6 to 0.8 kBtu/ft² yr (≈80%)
  - Adjacent floor 4.6 to 4.4 kBtu/ft² yr (≈5%)

Fraunhofer IBP

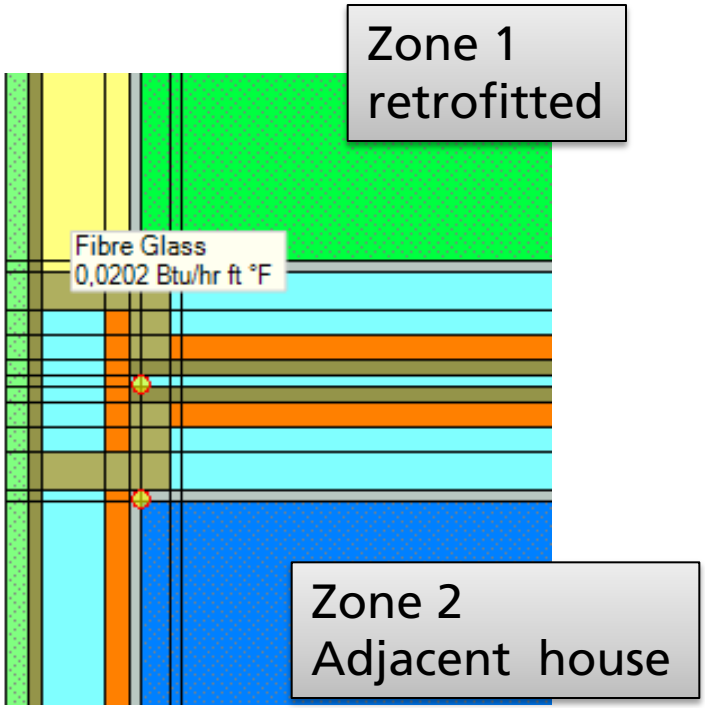
Wood frame construction – San Francisco

Cross section of the junction of **exterior** and **party wall**

Prior retrofit



Past retrofit

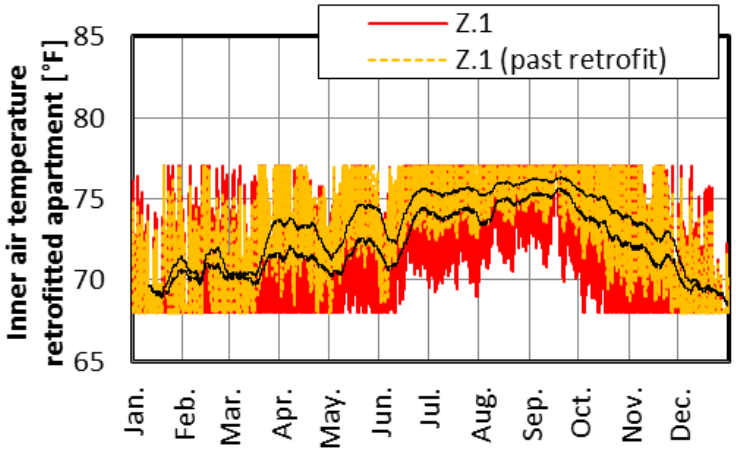


Fraunhofer IBP

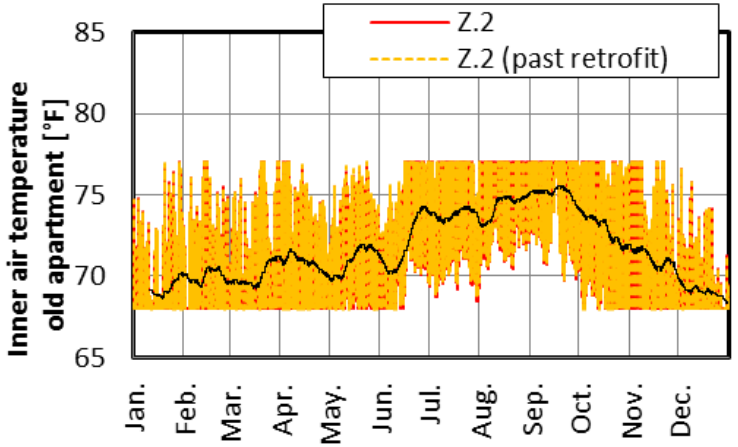
Wood frame construction – San Francisco

Results – Inner air temperature

Retrofitted house



Adjacent house

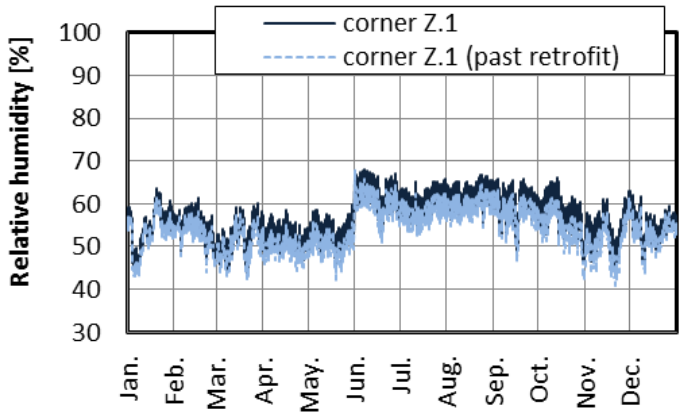


Fraunhofer IBP

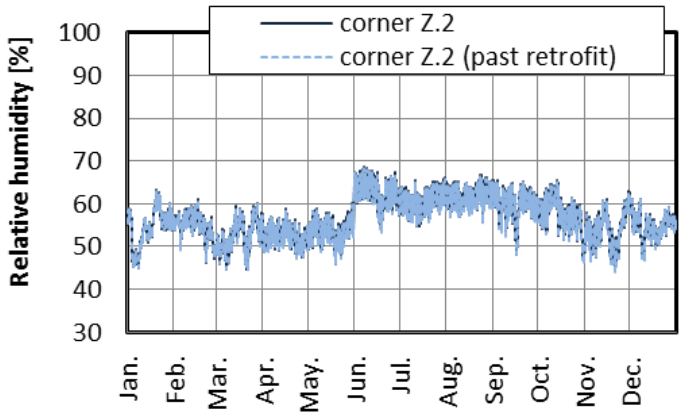
Wood frame construction – San Francisco

Results – moisture risk on the junction exterior - party wall

Retrofitted house



Adjacent house



- Retrofit will not increase the moisture risk in the neighboring structure in the critical exterior wall – party wall corner

Fraunhofer IBP

Wood frame construction – Chicago (5A)

Wood frame construction – Chicago

Building Assemblies / Material

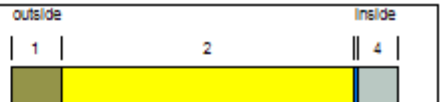
neighboring and retrofitted **woof frame** construction: **exterior wall**

Homogenous layers

Thermal resistance: 14,073 hr ft² °F/Btu

Heat transfer coefficient(U-value):

Thickness: 4,622 in



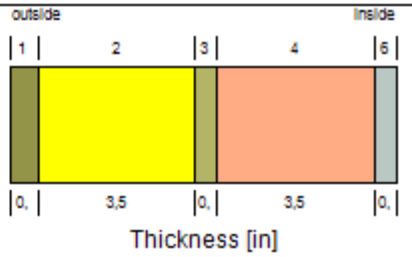
Nr.	Material/L (from outside t
1	Plywood (USA)
2	Mineral Wool (heat cond.: 0,04 V
3	vapor retarder (5perm)
4	Gypsum Board (USA)

Homogenous layers

Thermal resistance: 36,683 hr ft² °F/Btu

Heat transfer coefficient(U-value): 0,03 Btu/hr ft² °F

Thickness: 8,614 in



Nr.	Material/Layer (from outside to inside)	ρ [lb/ft³]	c [Btu/lb°F]	λ [Btu/hr ft °F]	Thickness [in]	Color
1	Plywood (USA)	29,34	0,45	0,0485	0,591	
2	Mineral Wool (heat cond.: 0,04 W/mK)	3,75	0,2	0,0231	3,5	
3	Fibreboard Plain low	14,84	0,45	0,026	0,492	
4	Polyisocyanurate Insulation	1,65	0,35	0,0139	3,5	
5	Vapor retarder (5perm)	8,12	0,55	1,3289	0,039	
6	Gypsum Board (USA)	53,06	0,21	0,0942	0,492	

+ new interior insulation (double stud)

Fraunhofer IBP

Wood frame construction – Chicago

Building Assemblies / Material

neighboring and retrofitted **brick** construction: **Party wall**

Homogenous layers

Thermal resistance: 12,186 hr ft² °F/Btu

Heat transfer coefficient(U-value): 0,07 Btu/hr ft² °F

Thickness: 9,661 in

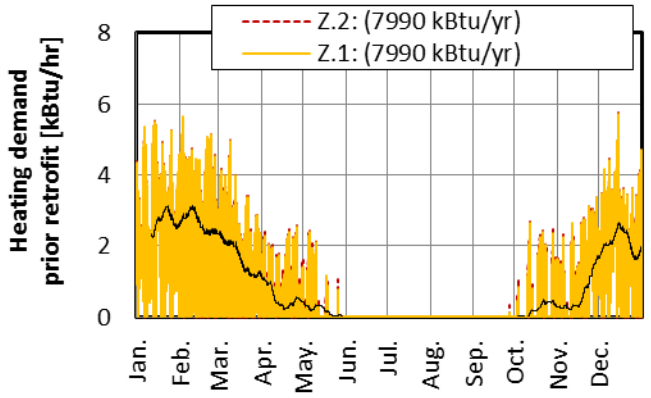
Nr.	Material/Layer (from outside to inside)	ρ [lb/ft³]	c [Btu/lb°F]	λ [Btu/hr ft °F]	Thickness [in]	Color
1	Gypsum Board (USA)	53,06	0,21	0,0942	0,492	
2	Air Layer 25 mm	0,08	0,24	0,0896	2,5	
3	Wood-Wool Board	28,09	0,36	0,0462	0,952	
4	Plywood (USA)	29,34	0,45	0,0485	0,591	
5	Air Layer 10 mm	0,08	0,24	0,041	0,591	

Not refurbished

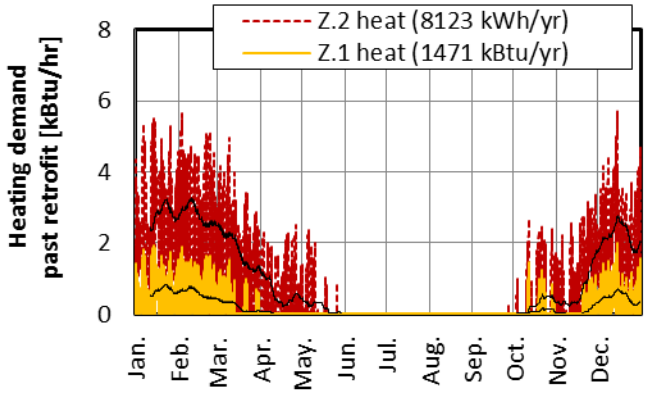
Wood frame construction – Chicago

Simulation results – Heating demand

Prior retrofit



Past retrofit

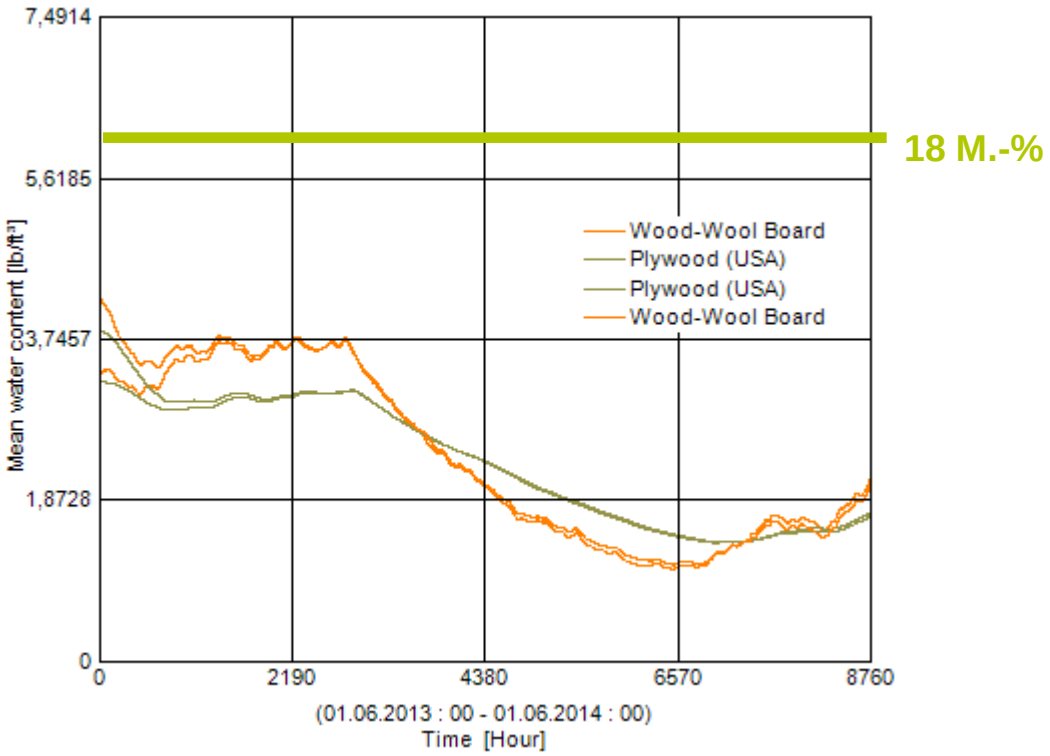


- Decrease of the heating demand
  - Retrofitted floor 14.9 to 2.7 kBtu/ft² yr (≈81%)
  - Adjacent floor 14.9 to 14.6 kBtu/ft² yr (≈1.5%)

Fraunhofer IBP

Wood frame construction – Chicago

Mean layer water content – Inner Wall materials

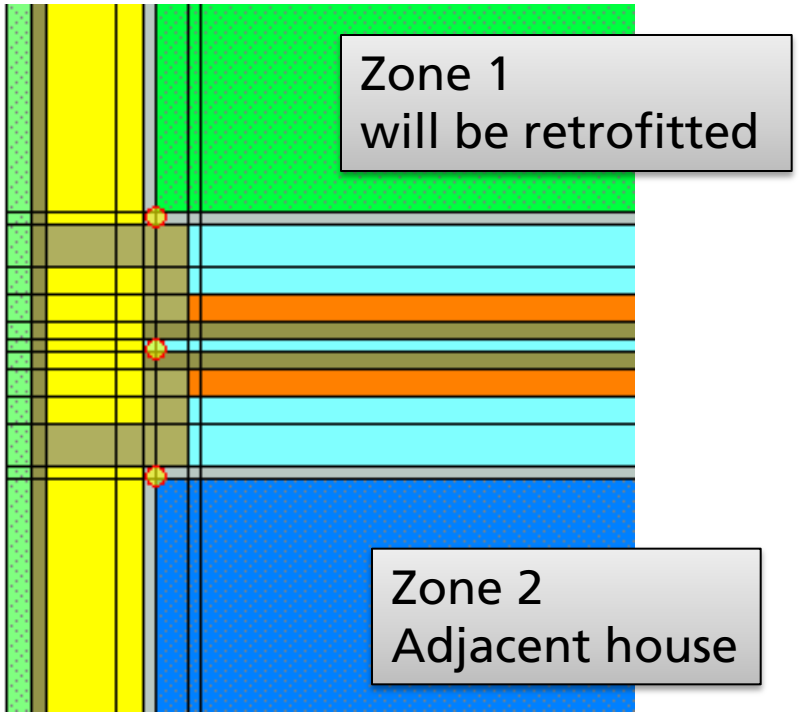


Fraunhofer IBP

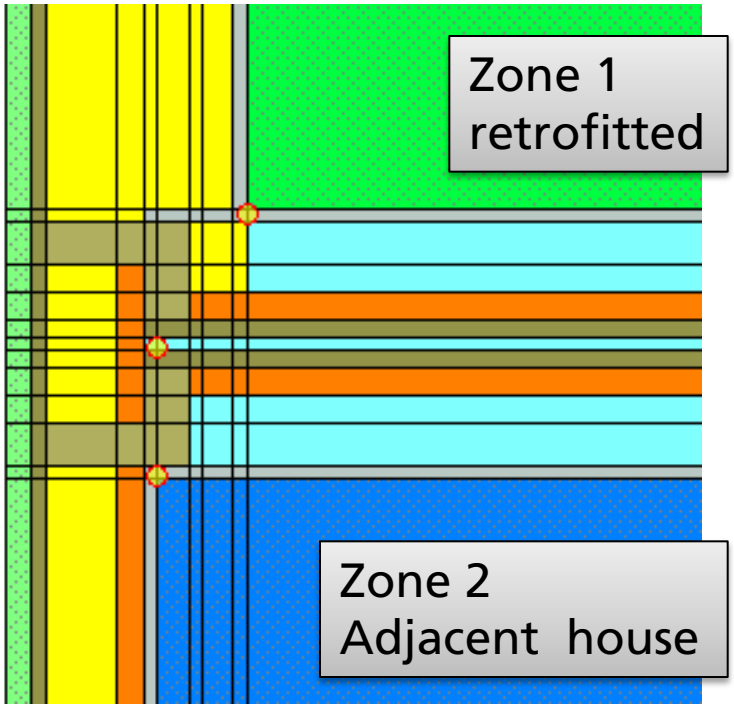
Wood frame construction – Chicago

Cross section of the junction of **exterior** and **party wall**

Prior retrofit



Past retrofit

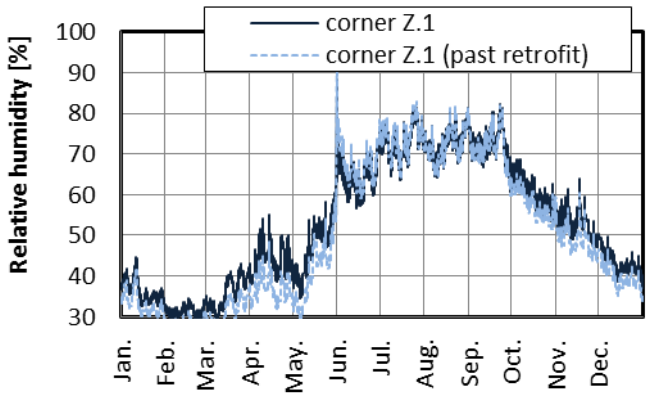


Fraunhofer IBP

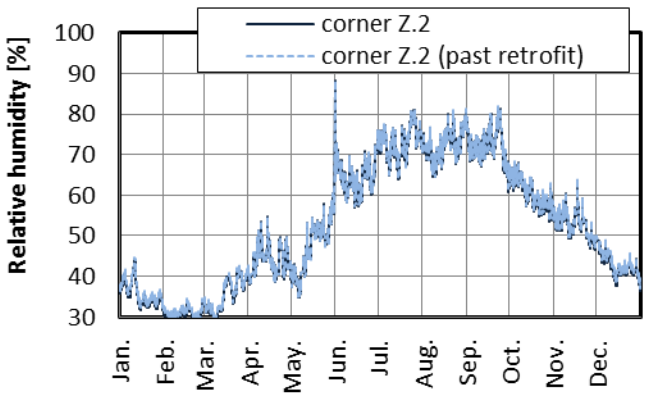
Wood frame construction – Chicago

Results – moisture risk on the junction exterior - party wall

Retrofitted house



Adjacent house

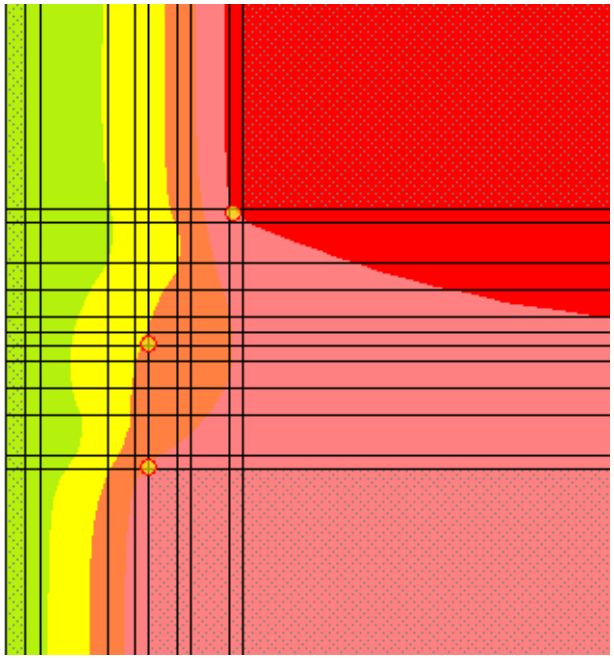


- Retrofit will not increase the moisture risk in the neighboring structure in the critical exterior wall – party wall corner

Fraunhofer IBP

Wood frame construction – Chicago

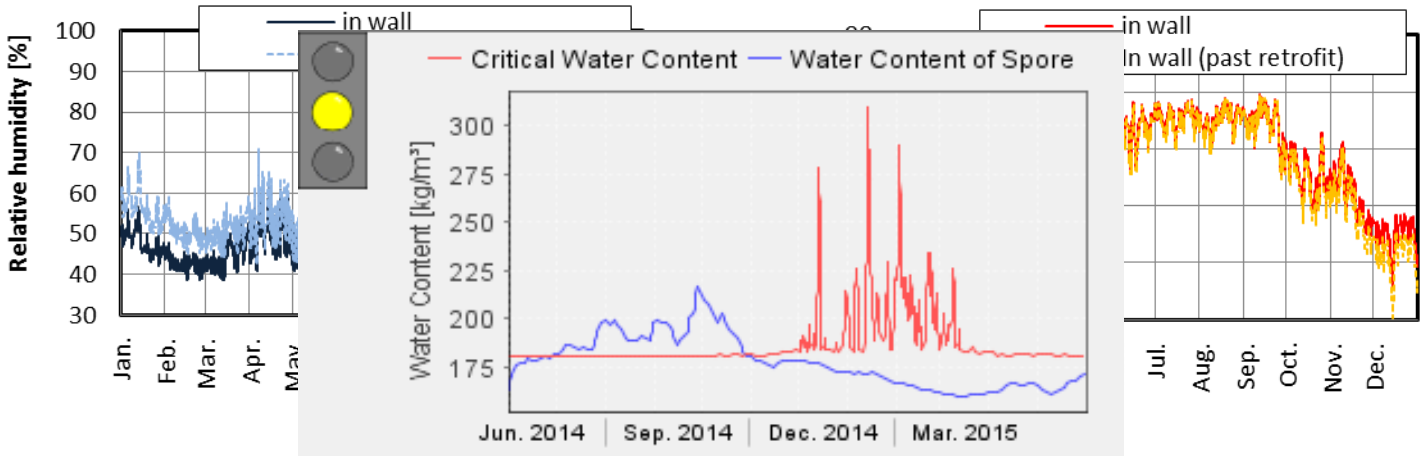
Results – moisture risk on the junction exterior - party wall



Wood frame construction – Chicago

Results – moisture risk on the junction exterior - party wall

Retrofitted house | **Between the studs** | Adjacent house



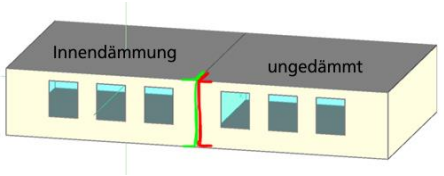
- Retrofit can increase the moisture risk in the middle of the double stud party wall

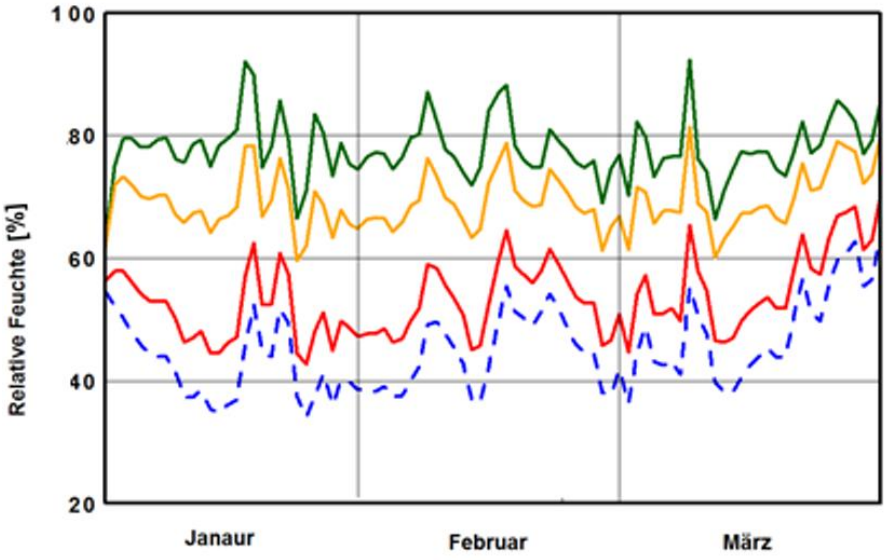
Fraunhofer IBP

Varying Simulation Parameters

Varying Simulation Parameters

- with / without interior insulation





Air temperature (both)

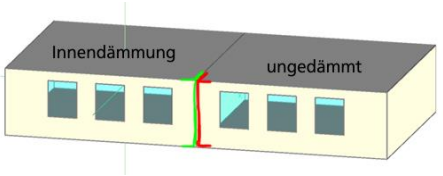
Corner without interior insulation

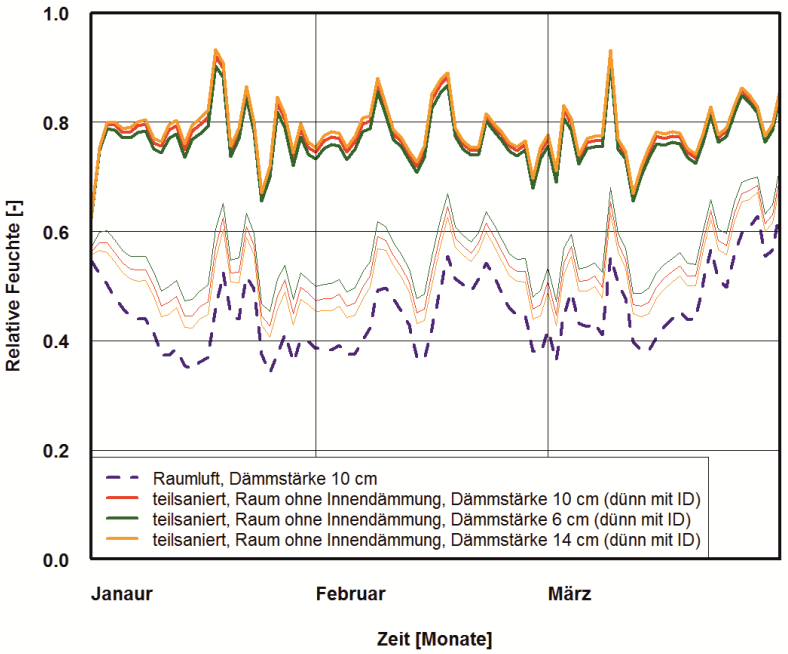
Corner with interior insulation

Reference case

Varying Simulation Parameters

- Depending on insulation thickness





Air temperature (both)

2.4 in

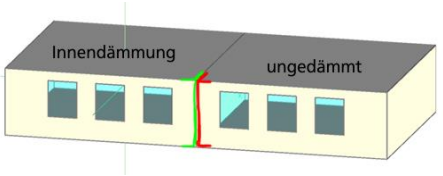
4.0 in

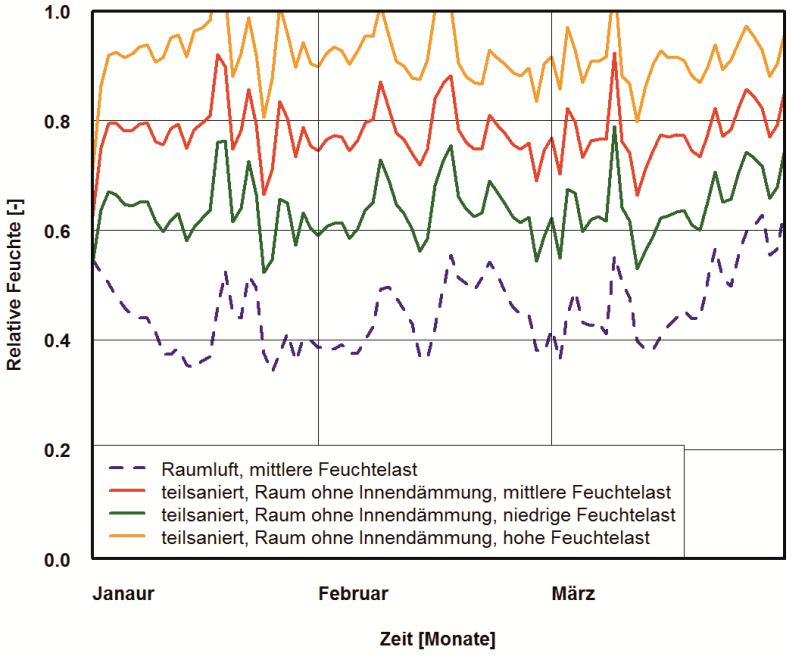
5.5 in

Fraunhofer IBP

Varying Simulation Parameters

- Depending on moisture load





Air temperature (both)

low

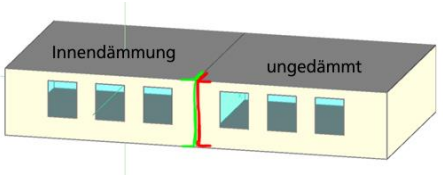
mid

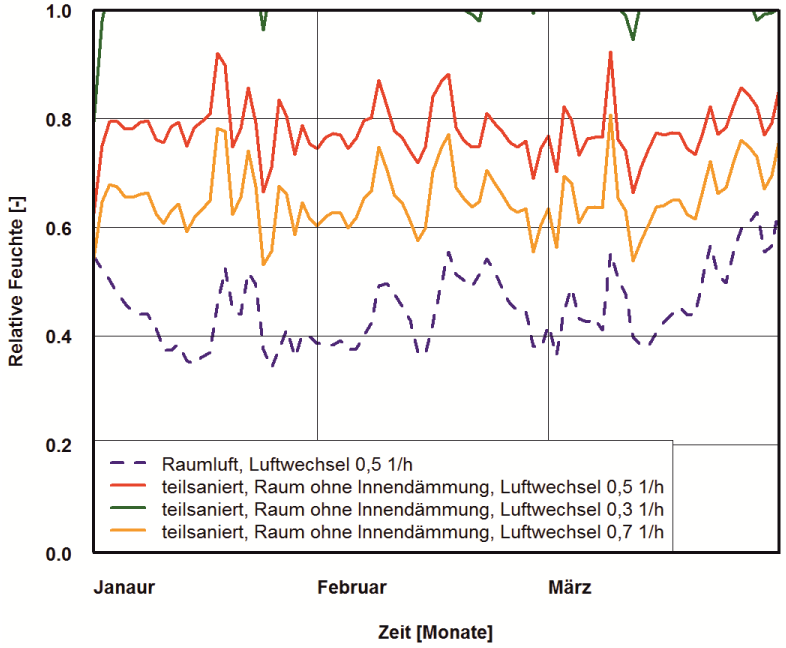
high

Fraunhofer IBP

Varying Simulation Parameters

- Depending on air change



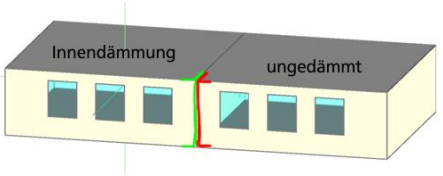


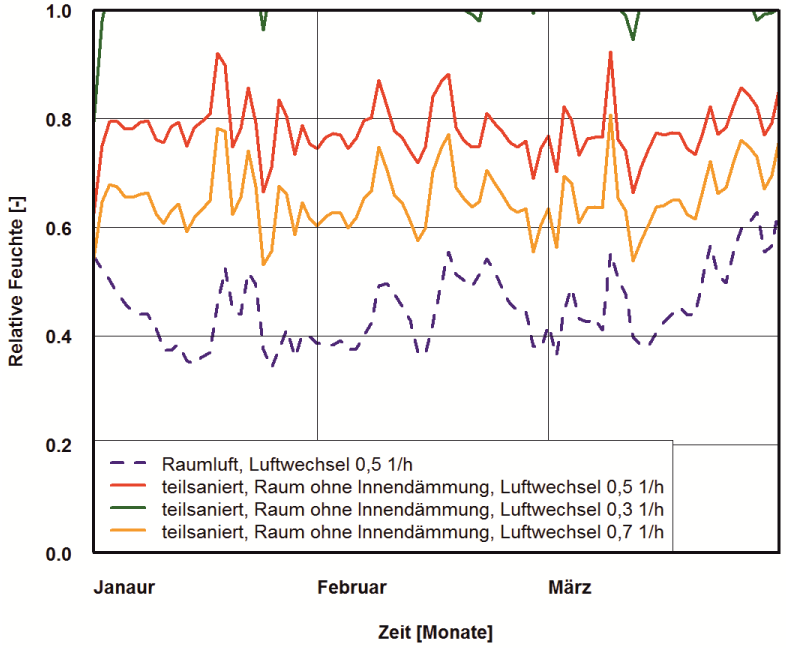
- Air temperature (both)
- 0.3 ach
- 0.5 ach
- 0.7 ach

Fraunhofer IBP

Varying Simulation Parameters

- Depending on air change





- Air temperature (both)
- 0.3 ach
- 0.5 ach
- 0.7 ach

Fraunhofer IBP

Summary

- Moisture risks of passive retrofitting one town house for the adjacent conventional neighboring structures can be investigated with WUFI Passive
- risks depend on
  - construction type / material / redevelopment
  - climate zone
  - user behavior / air change
  - less on interior insulation thickness