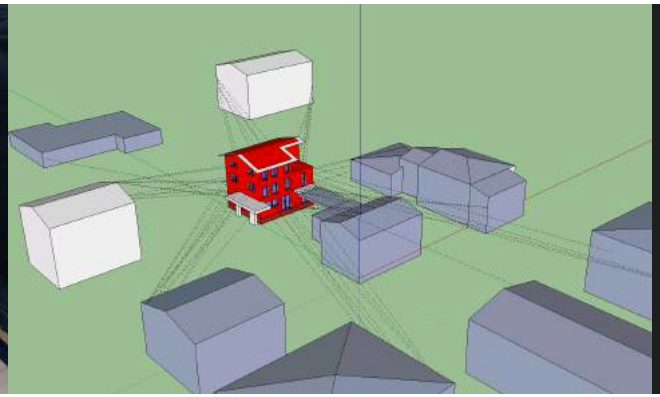
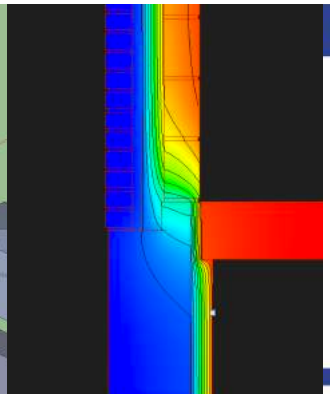
Cost-effectiveness of retrofits in Italy to the EnerPHit standard

2017 South Pacific Passive House Conference, Christchurch, New Zealand

Emu – from architects to systems



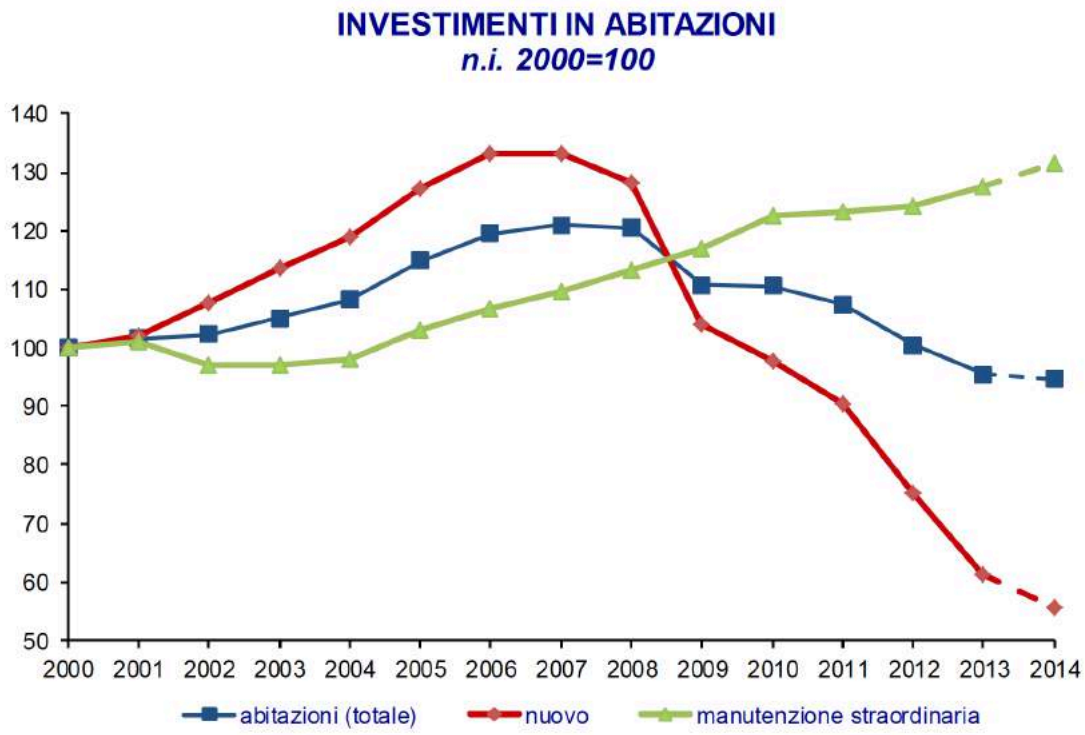

Summary

- Context: what are the Italians up to today
- Case study: retrofit of single-family house to EnerPHit standard
- The way forward: bringing Passive House to mainstream market

Context: Italy

Construction market

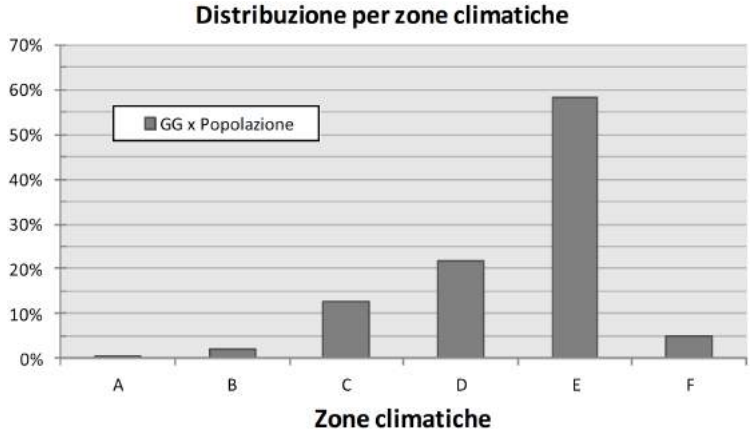
- Since 2008, investments in new construction have dropped by 62.7%
- Investments in retrofits have increased by 23.6%

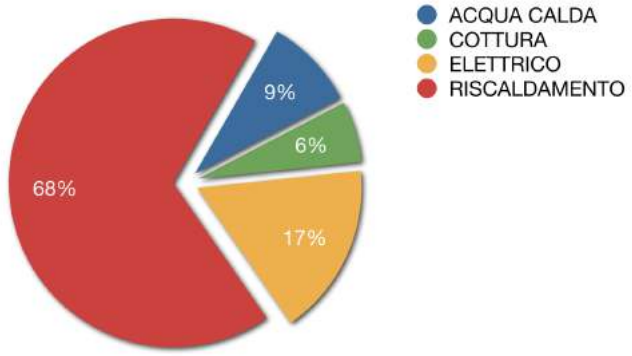


...population growth in Italy has been near zero for over 30 years

Culture vs climate

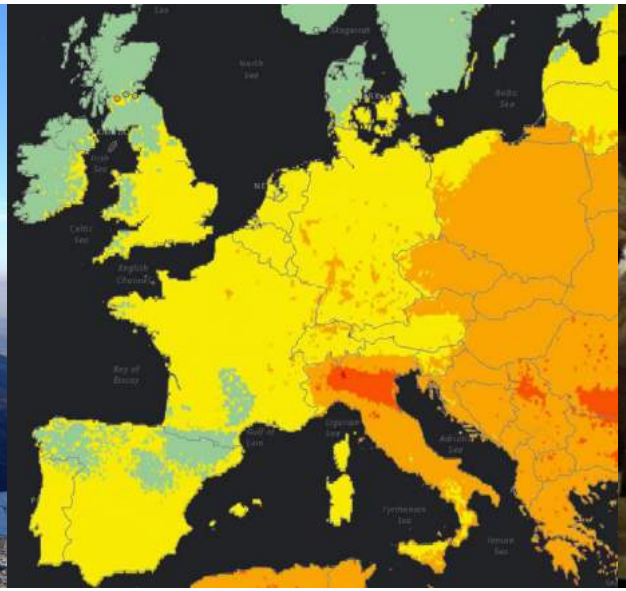
- Italian climate is warm
- Reality: 65% of population lives in heating-dominated climate
- National average: 2/3 of residential use of energy is heating





Environment

- Northern Italy: one of the most polluted areas in the world



Economy

- Cost of electricity per kWh:

Italy: 0.18 € Germany: 0.25 € US: 0.10 € (0.11 $)

- Cost of natural gas per kWh:

Italy: 0.08 € Germany: 0.07 € US: 0.03 € (0.03 $)

- Cost of energy: **constant** over time (for ROI analyses here)
- Interest rate: 2.5% Inflation rate: 0.5%

Tax breaks for energy retrofit in Italy

- **Retrofits** of existing residential buildings, where heating is installed

  include thermal insulation, replacement of windows, shading, changes to heating/cooling system, etc.

  does not cover mechanical ventilation

- Up to **100.000 €** deductible per unit, in over **10 years**

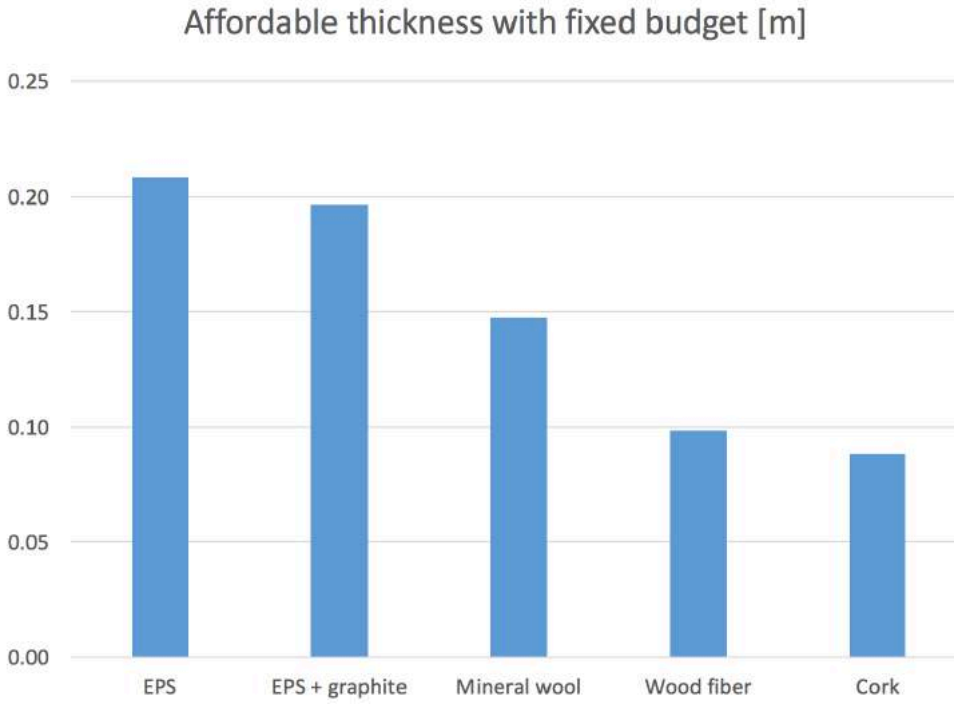
- Apply to personal income tax

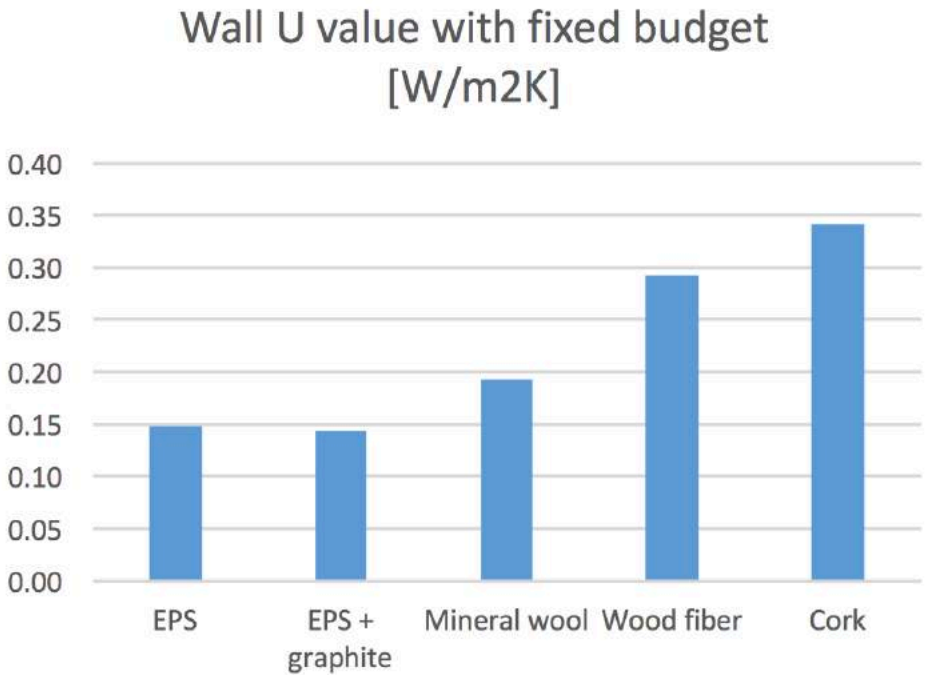
  pay out of pocket

  deduct 65% of expenses from taxes later (over 10 years)

Cost-effectiveness of insulation

- What can I buy for the same amount of money? (*)

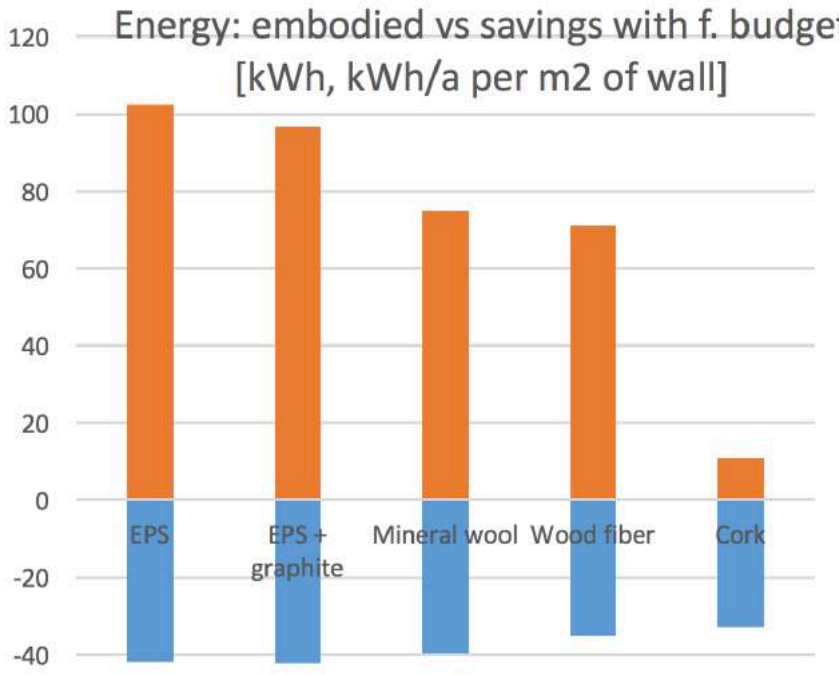


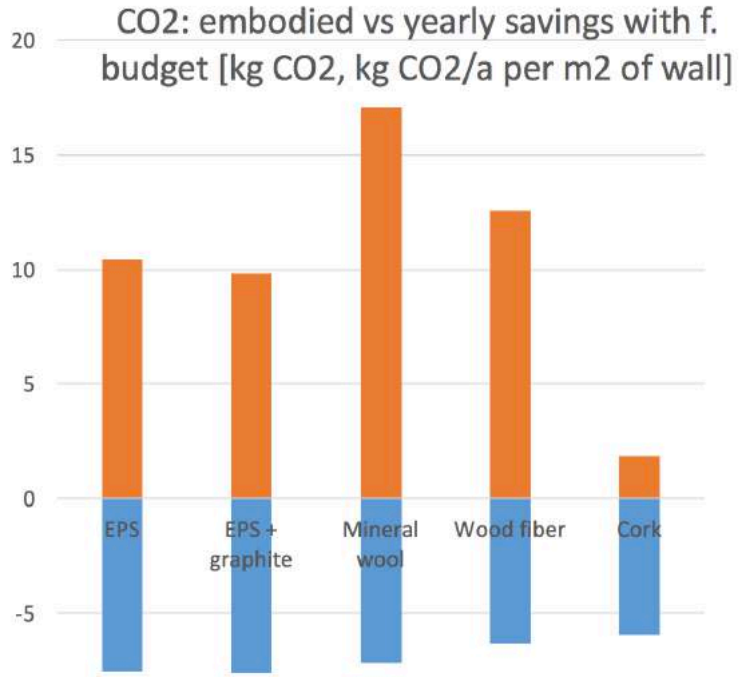


(*) 70.00 €/m2, includes EIFS components, labor, scaffolding, pre-tax, no tax breaks

Cost-effectiveness of insulation

- How good is the insulation I buy?



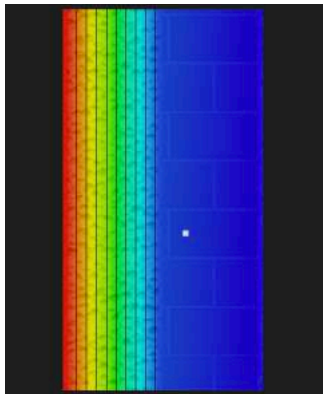


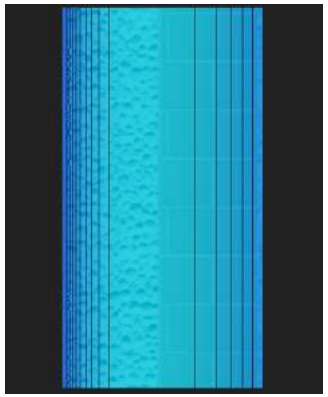
61 kKh/a heating, via air-to-water HP (COP 2.8)

Cost-effectiveness of insulation

- What performance am I buying?

		static performance		dynamic performance		
EIFS insulation used	insulation thickness on same budget [cm]	U value [W/m2K]	EnerPHit suitable?	Yie value [W/m2K]	thermal lag [h]	thermal attenutation [-]
EPS	21	0.15	Y	0.016	12h 25'	0.100
EPS + graphite	20	0.14	Y	0.019	12h 13'	0.126
Mineral wool	15	0.19	Y	0.023	13h 50'	0.112
Wood fiber	10	0.29	N	0.036	14h 17'	0.109
Cork	9	0.34	N	0.051	12h 32'	0.130





static transmittance according to ISO6946, dynamic transmittance to ISO13786

Building stock

- Substantial part built between 60s and 90s
- Most common technique: masonry, often with concrete frame
- Hardly any insulation
- No mechanical ventilation (only 1% of buildings has it)

Case study: single-family house

Existing conditions

- Built in 1962 as house of a marble dealer
- Brick masonry with some concrete element
- Mixed use:
  - ground fl.: workshop and deposit
  - 2nd:one resitential unit
  - attic: unheated storage for house
- Good orientation, poor form factor of heated part

Existing conditions

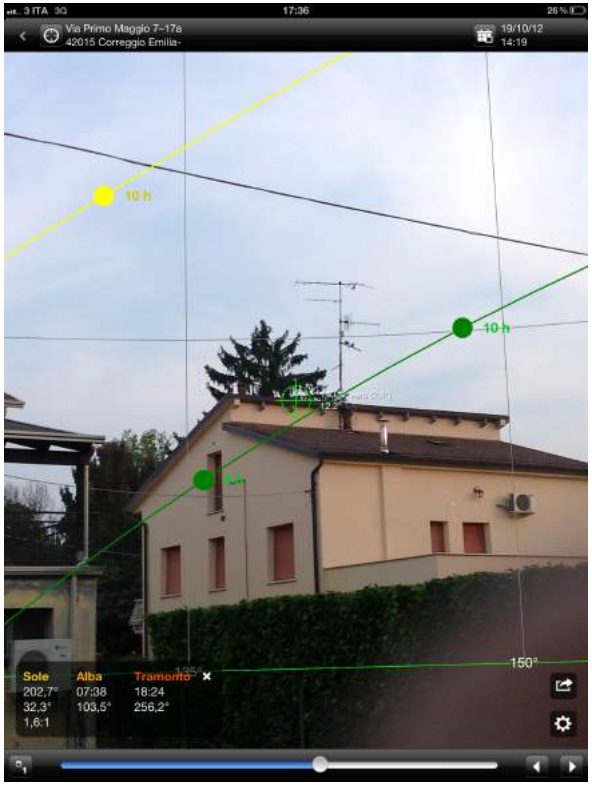
view from north-east

view from south-west

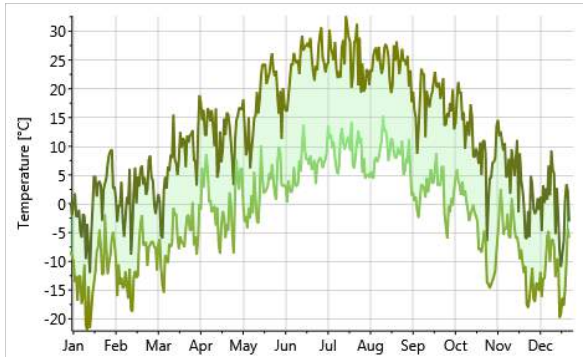
detail of masonry

Surroundings – site climate data

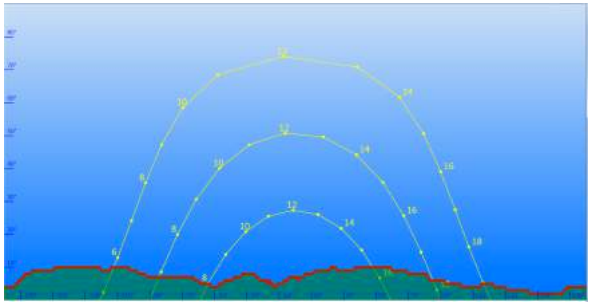
satellite



site horizon survey

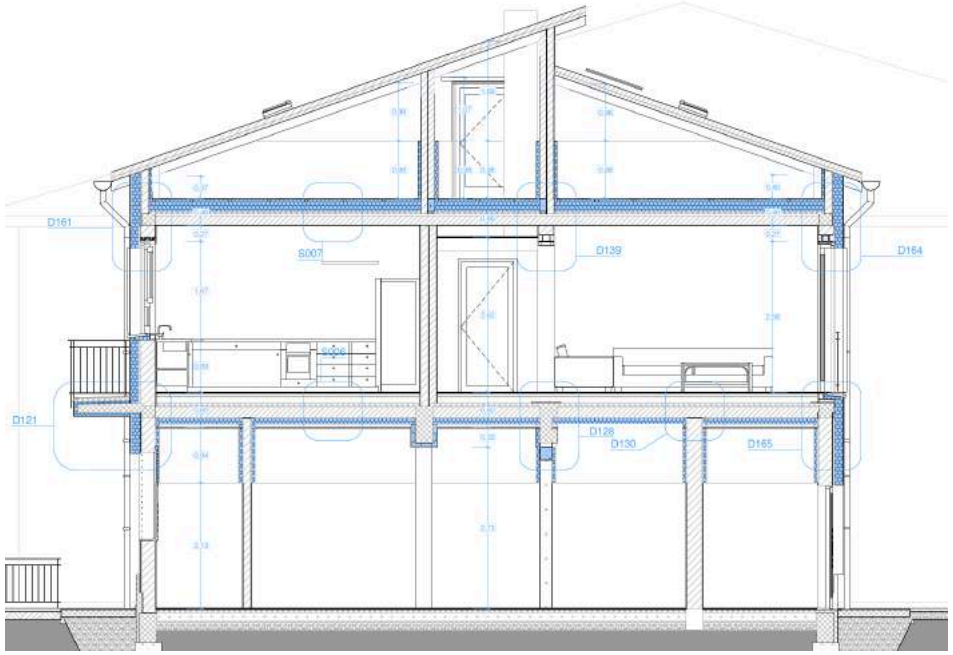


project climate data

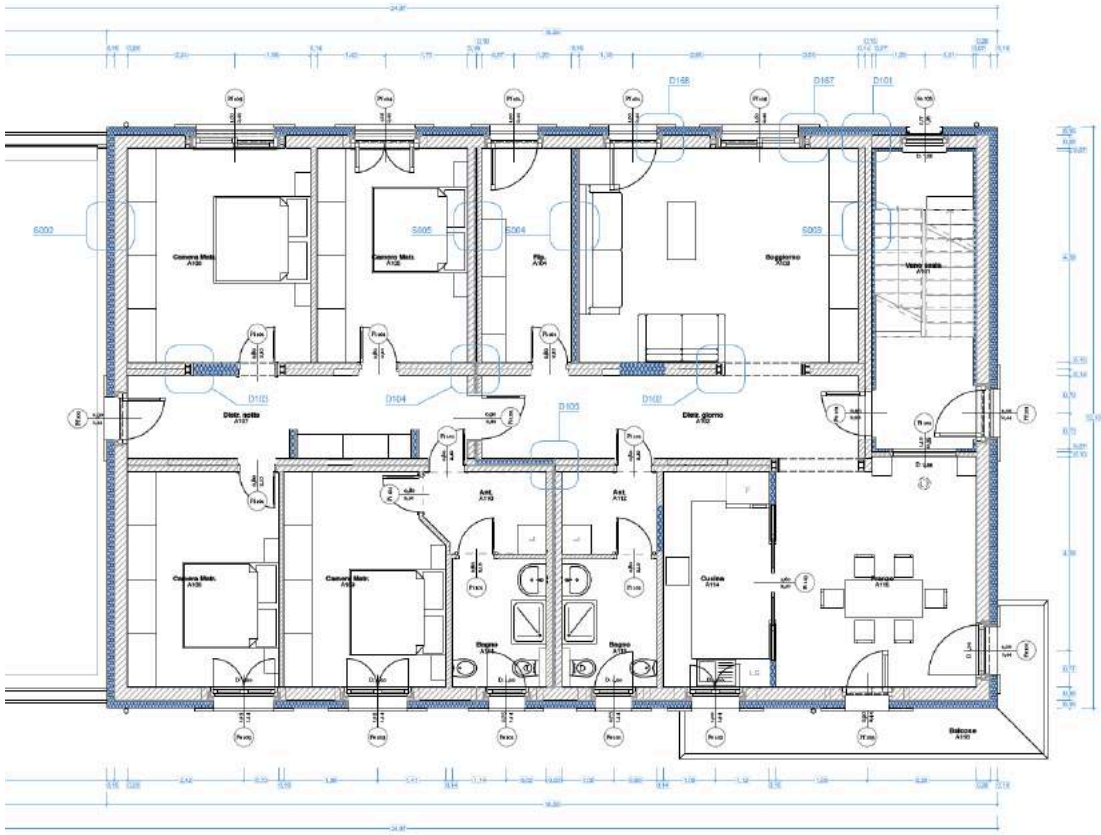


project horizon

Retrofit project

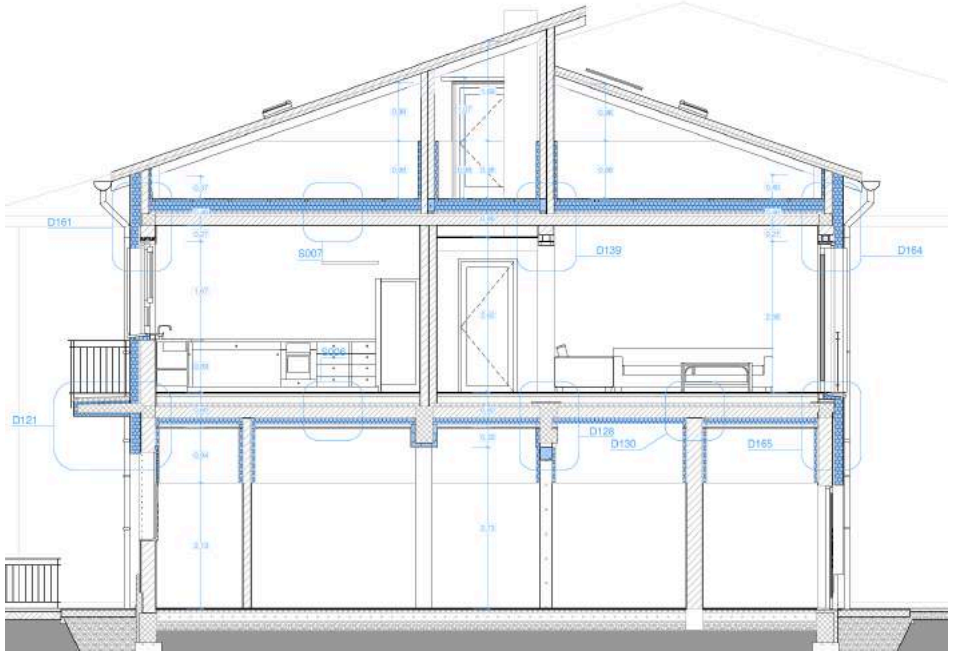


cross section



2nd storey floorplan (heated)

Baseline works + budget

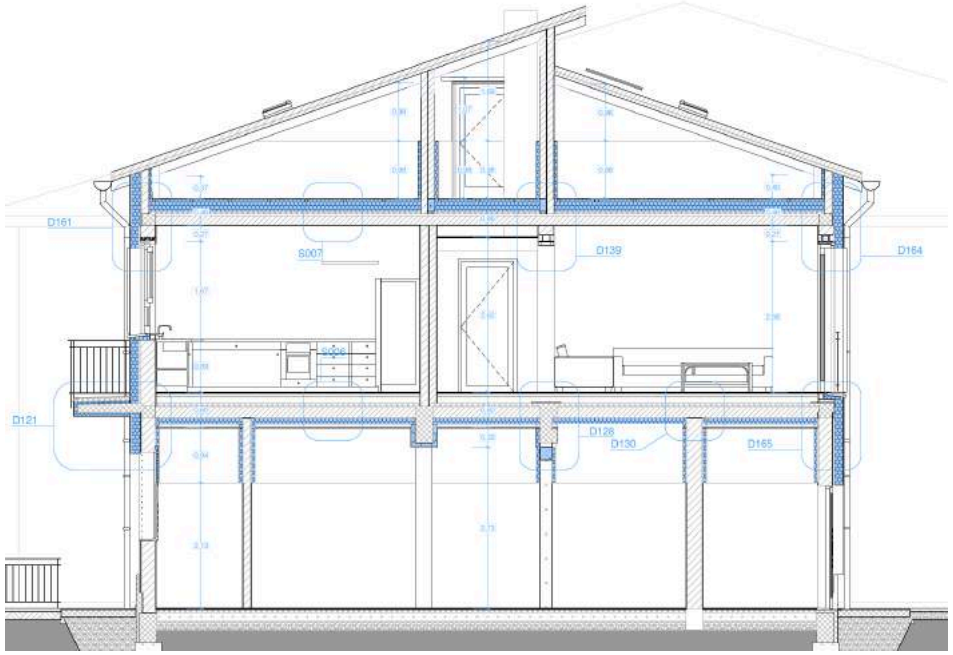


cross section

- Seismic improvements to the building structure
- Major redistribution of internal spaces (2nd storey)
- Design for future separation into two apartments
- Insulate envelope, replace windows
- Re-do all services, add mechanical ventilation

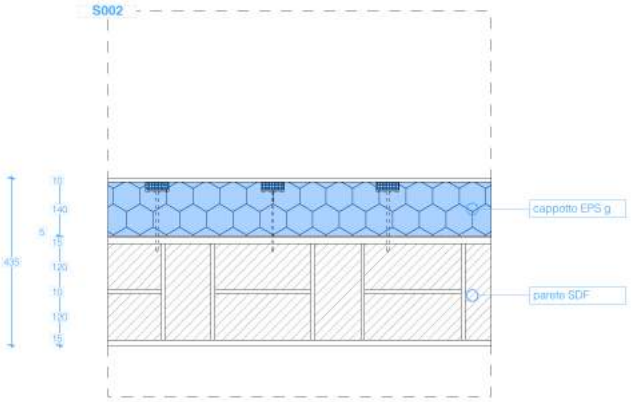
Baseline budget: **255.000 €** + tax

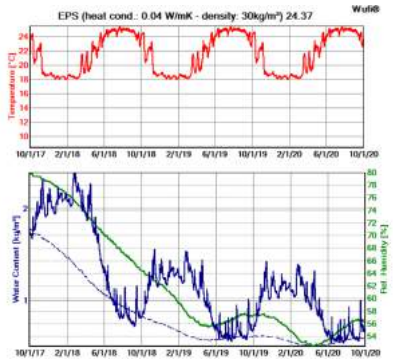
Assemblies: physics

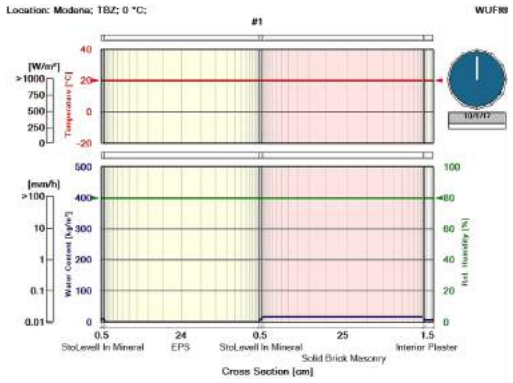


cross section

- Assembly analysis

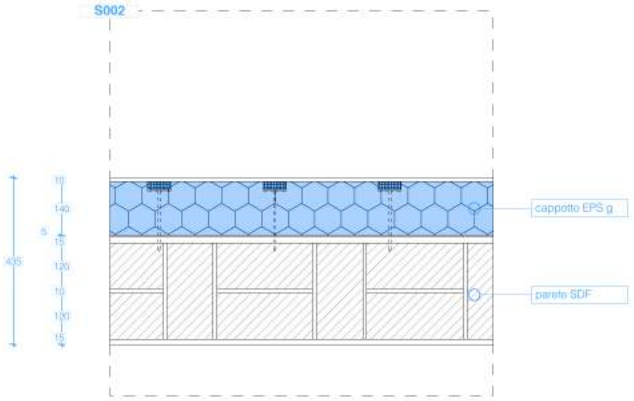


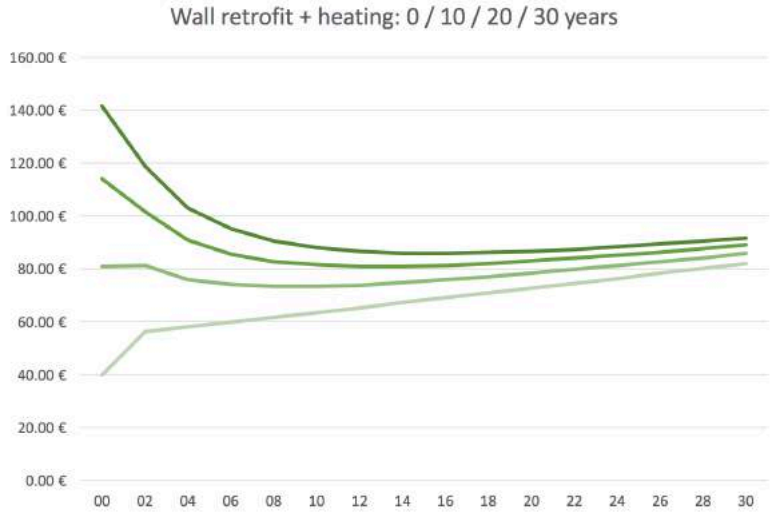




www.emu.systems

Assemblies: physics + budget

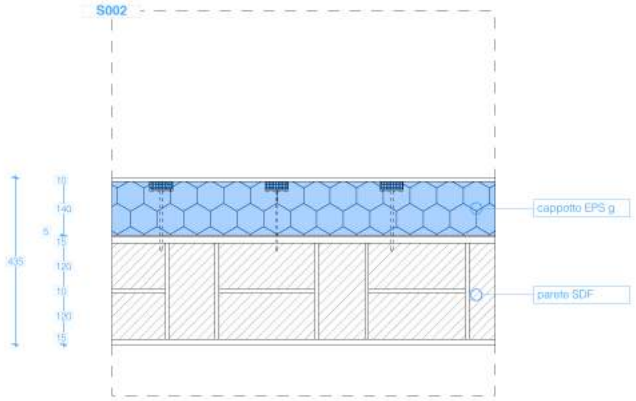


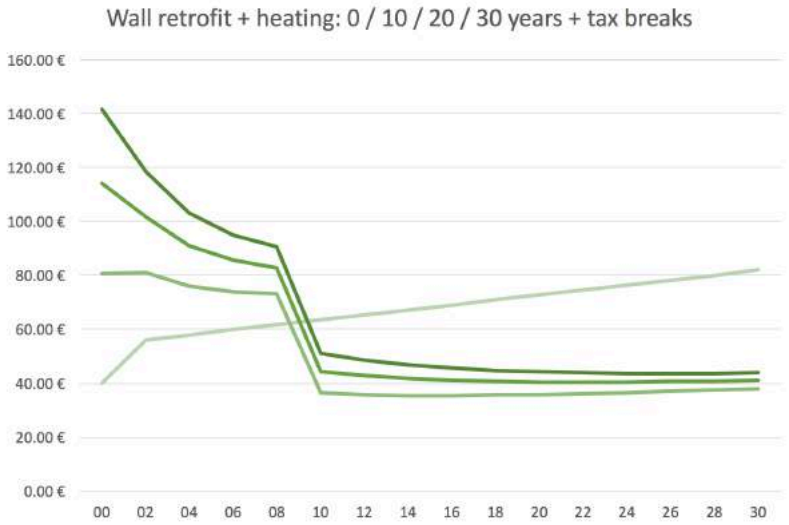


thickness [cm]	00	02	04	06	08	10	12	14	16	18	20	22	24	26	28	30
R [m2K/W]	0.9665	1.5726	2.1786	2.7847	3.3908	3.9968	4.6029	5.2090	5.8150	6.4211	7.0271	7.6332	8.2393	8.8453	9.4514	10.0574
U [W/m2K]	1.0346	0.6359	0.4590	0.3591	0.2949	0.2502	0.2173	0.1920	0.1720	0.1557	0.1423	0.1310	0.1214	0.1131	0.1058	0.0994
cost of construction	€ 40.00	€ 56.15	€ 57.99	€ 59.83	€ 61.67	€ 63.51	€ 65.35	€ 67.19	€ 69.03	€ 70.87	€ 72.71	€ 74.55	€ 76.39	€ 78.23	€ 80.07	€ 81.91
constr. + heat 10y	€ 80.69	€ 81.16	€ 76.04	€ 73.95	€ 73.26	€ 73.35	€ 73.89	€ 74.74	€ 75.79	€ 76.99	€ 78.30	€ 79.70	€ 81.16	€ 82.67	€ 84.23	€ 85.82
constr. + heat 20y	€ 114.08	€ 101.67	€ 90.85	€ 85.54	€ 82.78	€ 81.42	€ 80.90	€ 80.93	€ 81.34	€ 82.02	€ 82.89	€ 83.92	€ 85.07	€ 86.32	€ 87.64	€ 89.02
constr. + heat 30y	€ 141.46	€ 118.51	€ 103.00	€ 95.04	€ 90.59	€ 88.04	€ 86.65	€ 86.01	€ 85.89	€ 86.14	€ 86.66	€ 87.39	€ 88.29	€ 89.31	€ 90.44	€ 91.66

61.32 kKh/a, EPS with graphite, 0.18 €/kWh, air-water heat pump (SCOP 2.8), interest 2.5%, inflation 0.5%

Assemblies: physics + budget + tax breaks

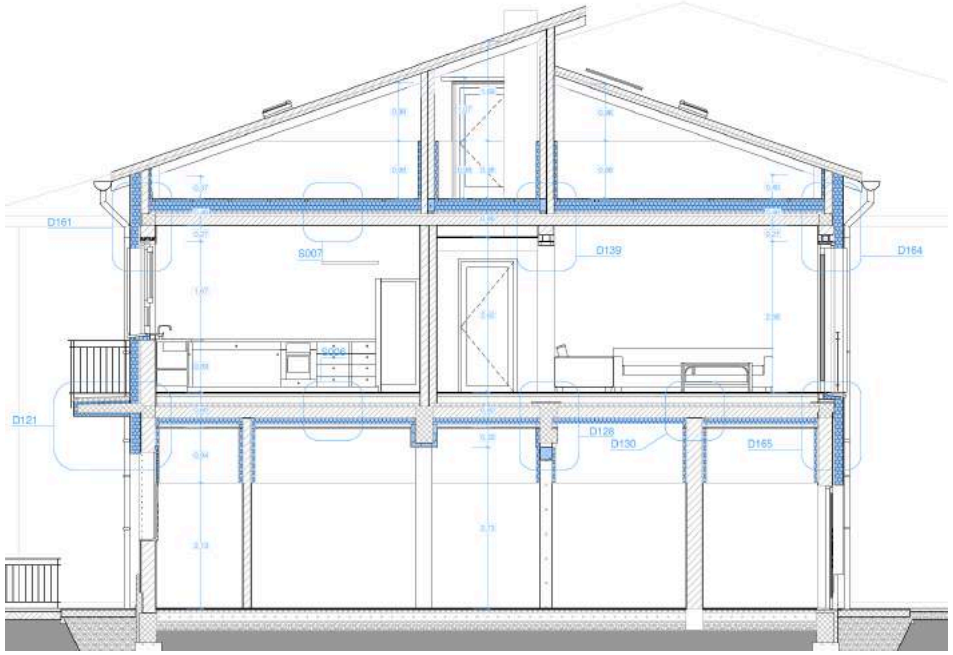




thickness [cm]	00	02	04	06	08	10	12	14	16	18	20	22	24	26	28	30
cost of construction	€ 40.00	€ 56.15	€ 57.99	€ 59.83	€ 61.67	€ 63.51	€ 65.35	€ 67.19	€ 69.03	€ 70.87	€ 72.71	€ 74.55	€ 76.39	€ 78.23	€ 80.07	€ 81.91
constr. + heat 10y + tax br.	€ 80.69	€ 81.16	€ 76.04	€ 73.95	€ 73.26	€ 36.27	€ 35.74	€ 35.51	€ 35.49	€ 35.61	€ 35.85	€ 36.17	€ 36.56	€ 37.00	€ 37.48	€ 37.99
constr. + heat 20y + tax br.	€ 114.08	€ 101.67	€ 90.85	€ 85.54	€ 82.78	€ 44.34	€ 42.75	€ 41.70	€ 41.04	€ 40.64	€ 40.44	€ 40.40	€ 40.48	€ 40.65	€ 40.89	€ 41.20
constr. + heat 30y + tax br.	€ 141.46	€ 118.51	€ 103.00	€ 95.04	€ 90.59	€ 50.96	€ 48.50	€ 46.78	€ 45.59	€ 44.76	€ 44.21	€ 43.87	€ 43.69	€ 43.64	€ 43.69	€ 43.83

tax breaks: deduct 65% of energy retrofit expenses from personal income tax, up to 100.000 € over 10 years

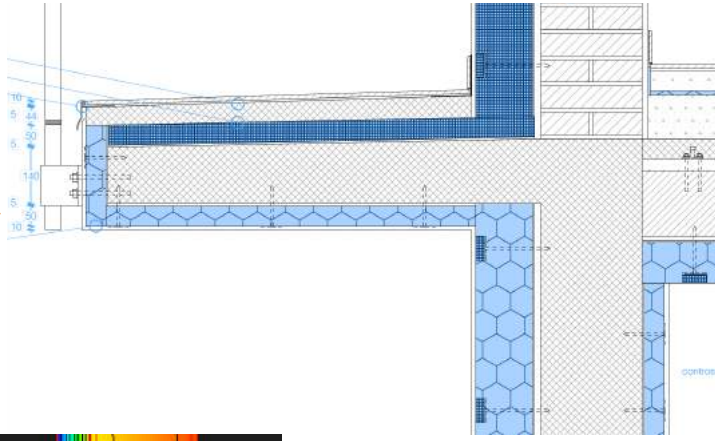
Envelope: Junctions



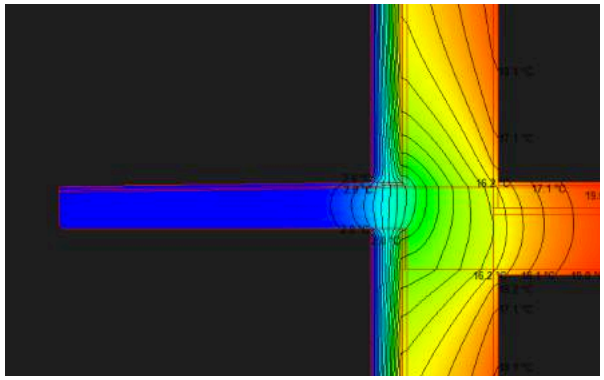
cross section

- Perimeter solid brick walls: structural, so please don't cut them
- Internal brick masonry walls (also structural)
- Balcony: concrete slab wrapping around corner (bonus: concrete colum)

Junctions: physics + budget



- Example: concrete balcony



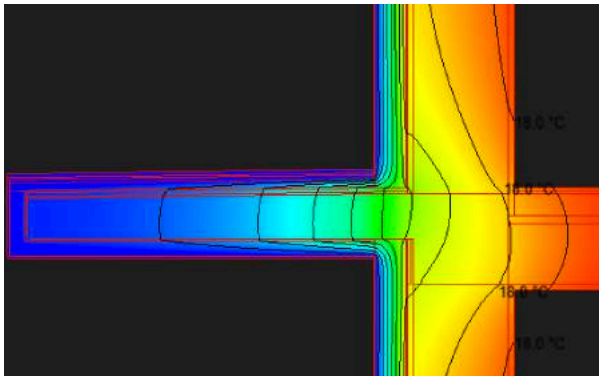
PSI = 0.662 W/mK

fRsi = 0.648

Te = 1.0 °C

Ti_min = 13.01 °C

mold: yes



PSI = 0.368 W/mK

fRsi = 0.841

Te = 1.0 °C

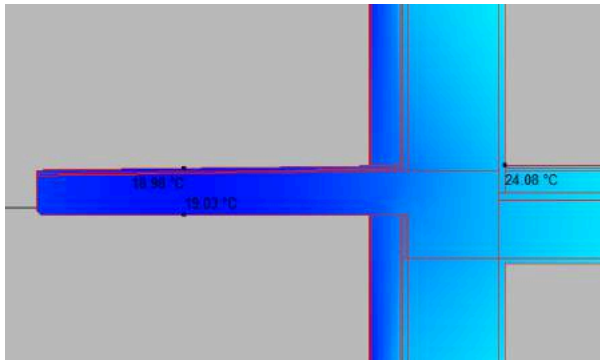
Ti_min = 16.98 °C

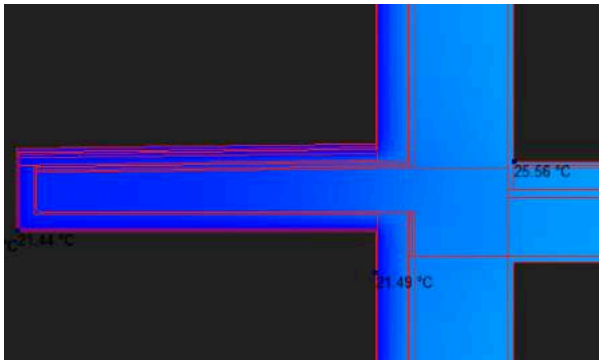
mold: no

cost: 105.00 €/m

ROI: 10 years

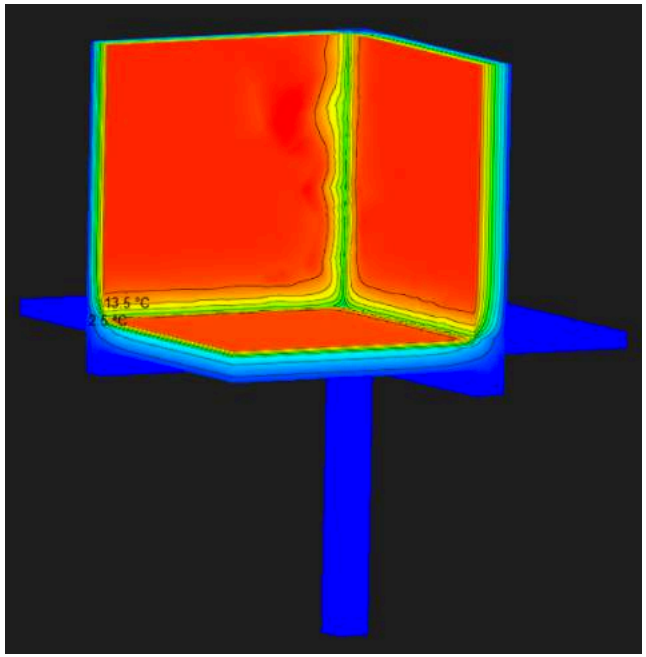
(not including tax breaks)





Junctions: 3D is the magic number

- Example: concrete balcony



As is:

CHI = 0.119 W/K

fRsi = 0.273

Te = 1.0˚C

Ti_min = 6.19 ˚C

mold: yes! yes! yes!

Retrofit:

CHI = -0.012 W/K

fRsi = 0.735

Te = 14.96 ˚C

mold: with mechanical ventilation, no

Whole building analysis – PHPP 9

- Building 'as is'
- Baseline: minimum for tax breaks (*)
- EnerPHit

av. U value: 1.44 W/m2K

46mm timber frame windows, single pane

high temperature radiators

no mechanical ventilatio

U value: 0.18 W/m2K

mm timber frame ndows, triple pane

eas with in-slab heating

chanical ventilation

EnerPHit

(*)Mechanical ventilation is not mandatory in Italy.

However, typical results of energy retrofits without mechanical ventilation is: mold and condensation. We don't do that.

Whole building analysis – PHPP 9

- Building 'as is'

HD: **280.5** kWh/m2a

HL: 116.1 W/m2

high temp. radiators

methane burner (old)

heating bill: **4.500** €/a

- Baseline: minimum for tax breaks (*)

HD: **51.2** kWh/m2a

HL: 31.1 W/m2

in-slab heating

air-to-water heat pump

heating bill: **610** €/a

- EnerPHit

HD: **17.7** kWh/m2a

HL: 13.1 W/m2

areas with in-slab heating

air-to-water heat pump

heating bill: **210** €/a

what is 'good enough'?

Whole building analysis – PHPP 9

- Building 'as is'

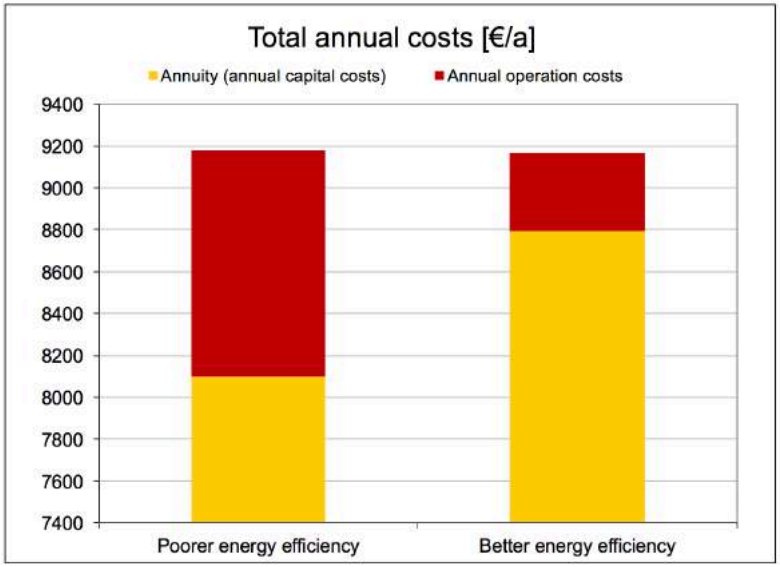
No tax breaks here

Total cost is very similar (EnerPHit slightly more convenient)

Poor form factor (you work with what you have)

Some components still very expensive (triple pane glass)

- Baseline: minimum for tax breaks (*)



- EnerPHit

+14 cm EIFS insulation

+14 cm floor insulation

+16 cm ceiling insulation

upgrade to 92 mm, triple pane windows

same insulation of thermal bridges

same mechanical ventilation units

less in-slab heating

upfront extra cost for EnerPHit: +22.000 € + 10% VAT (Jan 2016)

Whole building analysis – PHPP 9

- Building 'as is'

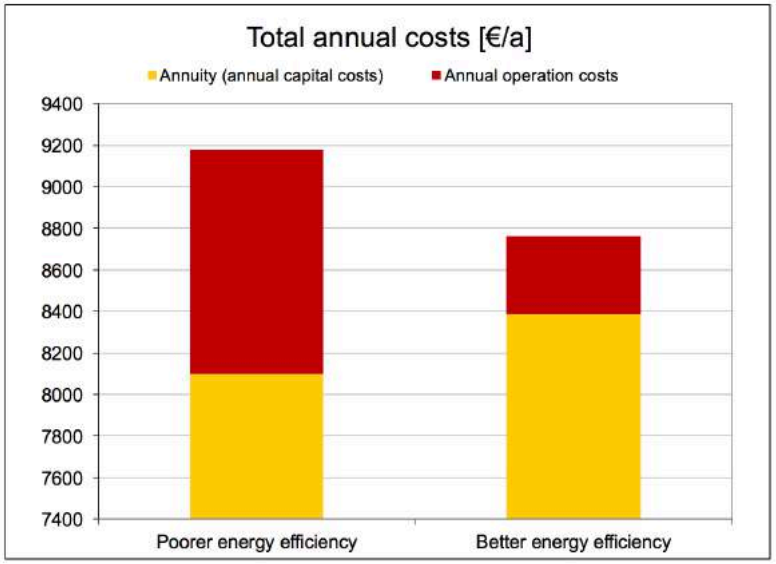
Can you pay out of pocket upfront?

Is your personal income tax high enough to deduct from?

Did you reach the 100k € deduction cap with other expenses?

Do you believe me?

- Baseline: minimum for tax breaks (*)



- EnerPHit

Extra cost: 22.000 €

Pot. extra tax break: 14.300 €

Present value: 12.800 €

Ok, let's do it!

...but not too fast

The way forward

Passive House consulting – a critique

- 25 years after, PH is still a niche
- The taylor-made approach is often a failure
- By winning beautiful battles, we risk to losethe war
- The battlefield that matters the most is mainstream market

Passive House 2.0

- Available at mainstream market price
- Adapt to local culture and climate
- Available to architects with basic training
- Available to trained tradespeople
- Integrate local products
- Becomes the baseline for comfort and efficiency

Simplify

- Learning from Lego

Simplify, standardize

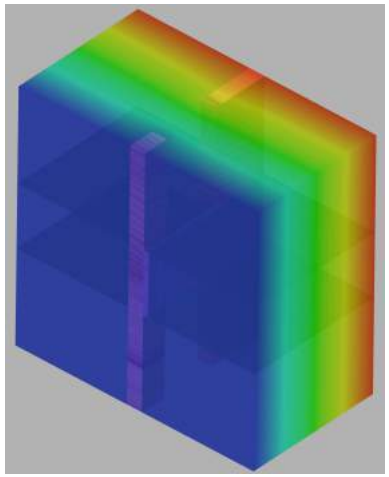
- Learning from Lego

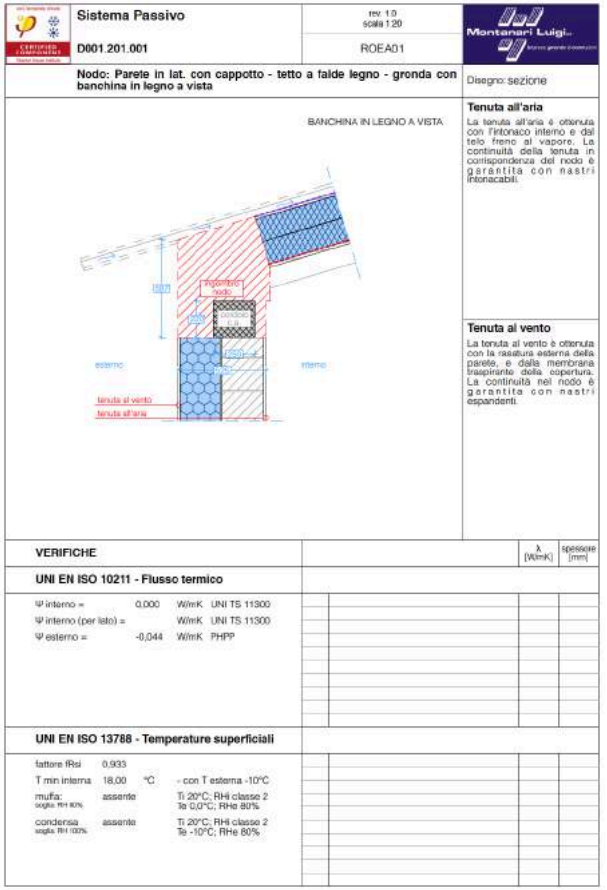
  Sizes of assemblies and junctions for architectural design

  Construction documentation

  Insulation, air tightness, wind tightness

  PSI value, fRsi value





Sistema Passivo

D001.201.001

rev. 1.0
scala 1:20

ROEA01

Montanari Luigi

Nodo: Parete in lat. con cappotto - tetto a falde legno - gronda con banchina in legno a vista

Disegno: sezione

BANCHINA IN LEGNO A VISTA

Tenuta all'aria

La tenuta all'aria è ottenuta con l'intonaco interno e dal telo freno al vapore. La continuità della tenuta in corrispondenza del nodo è garantita con nastri intonacabili.

Tenuta al vento

La tenuta al vento è ottenuta con la rasatura esterna della parete, e dalla membrana traspirante della copertura. La continuità nel nodo è garantita con nastri espandenti.

esterno

interno

tenuta al vento

tenuta all'aria

VERIFICHE

λ [W/mK]

spessore [mm]

UNI EN ISO 10211 - Flusso termico

Ψ interno =	0,000	W/mK	UNI TS 11300
Ψ interno (per lato) =		W/mK	UNI TS 11300
Ψ esterno =	-0,044	W/mK	PHPP

UNI EN ISO 13788 - Temperature superficiali

fattore fRsi	0,933		
T min interna	18,00	°C	- con T esterna -10°C
muffa: soglia RH 80%	assente		Ti 20°C; RHi classe 2 Te 0,0°C; RHe 80%
condensa soglia RH 100%	assente		Ti 20°C; RHi classe 2 Te -10°C; RHe 80%

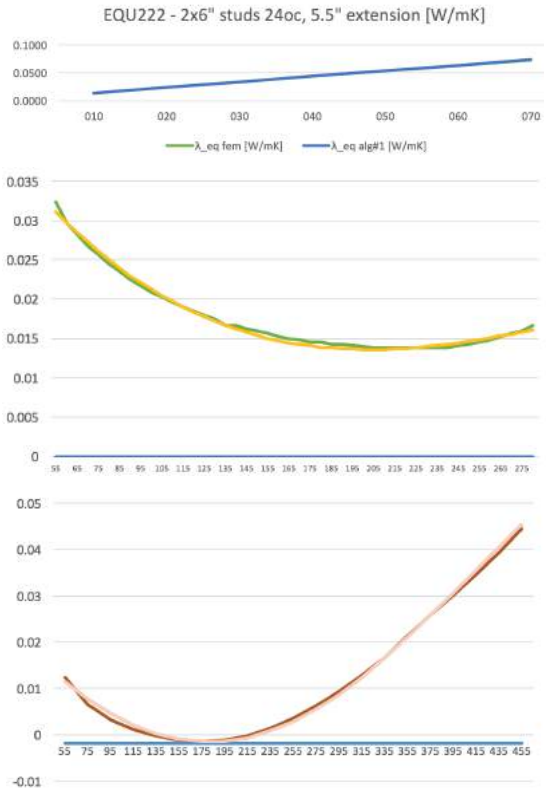
goal: simplify design and calculation of PH

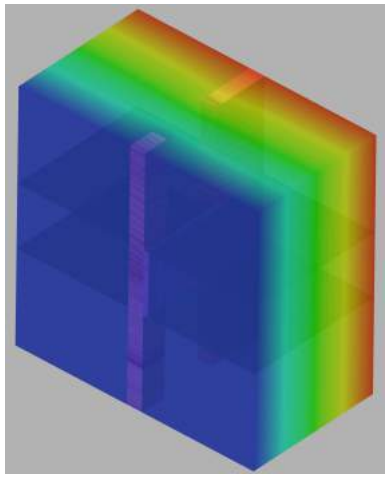
reality: may be perceived as rigid and unadaptable

emu

Simplify, standardize, integrate

- Learning from Lego





Sistema Passivo

D001.201.001

rev. 1.0
scala 1:20

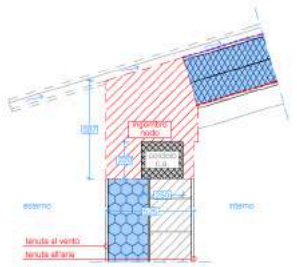
ROEA01

Montanari Luigi

Nodo: Parete in lat. con cappotto - tetto a falde legno - gronda con banchina in legno a vista

Disegno: sezione

BANCHINA IN LEGNO A VISTA



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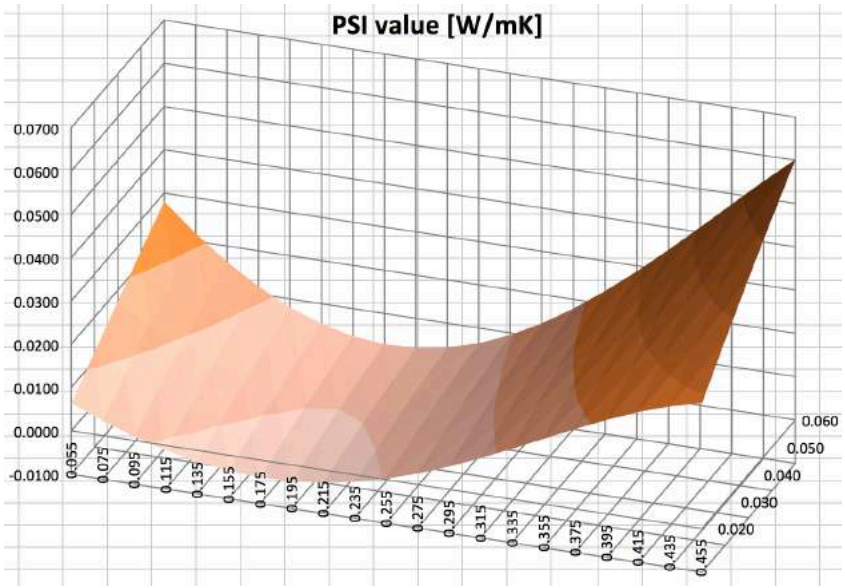
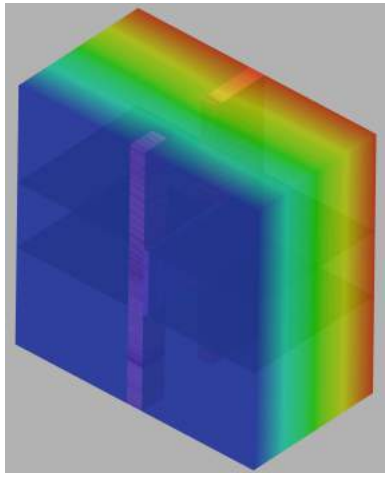
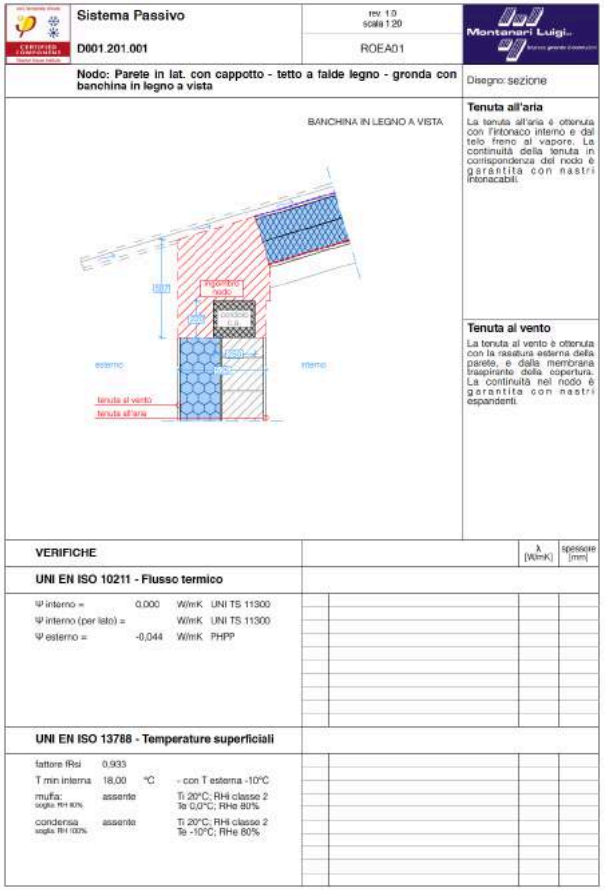
Simplify, standardize, integrate

- Learning from Lego



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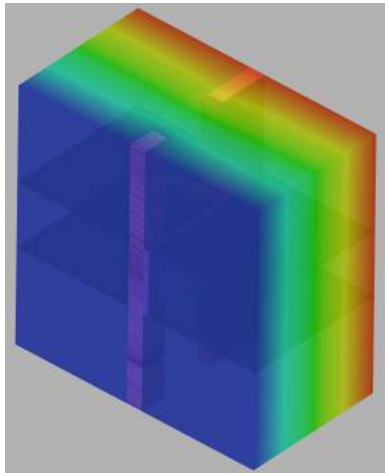
Simplify, train

- Learning from Lego



Standardized PH construcion systems

- 2016 - 1st system: Italian new construction (masonry)
- 2017 – 2nd system: North America new construction (timber frame)
- 2017 – 3nd system: Italian retrofit (masonry)
- ...?

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thank you